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COAST GUARD RESEARCH AND DEVELOPMENT CENTER GROTON CT F/G 9/2
ANALYST LEVEL DOCUMENTATION FOR THE SEARCH AND RESCUE SIMULATIO--ETC(U)
MAR 79 G L UNDERWOOD, J A SMITH, G B WALTERS

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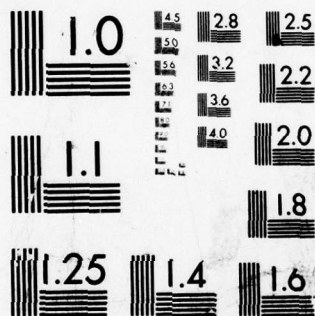
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Technical Report Documentation Page

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16. Abstract The Search and Rescue Simulation (SARSIM) is a management tool that has been developed to aid Coast Guard decision-makers in developing long-range strategic plans to carry out the SAR mission. SARSIM is a discrete event digital computer simulation program programmed in SIMSCRIPT II.5. It is a highly flexible user-oriented model that simulates Coast Guard response to futuristic caseloads. SARSIM is comprised of three major modules. The first major module is the PREPROCESSOR. The PREPROCESSOR is used to generate expected caseloads based on the historical SAR Data Base. In other words, it supplies a scenario, or futuristic caseload which may, if desired, be used for many different simulation runs. The heart of SARSIM, the SIMULATOR, is essentially a bookkeeping system which logs in cases, registers their needs, investigates the availability of service facilities, assigns resources for servicing, and generally keeps track of simulated time spent in the several possible activities represented within the model and maintains statistics for output. The POSTPROCESSOR is a data retrieval package, which operates on data files from the SIMULATOR to permit a more detailed analysis of simulation runs as a supplement to the printed report from the SIMULATOR.					
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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
teaspoon	teaspoons	5	milliliters	ml
fl oz	fluid ounces	15	milliliters	ml
c	cup	30	milliliters	ml
pt	pints	0.24	liters	l
qt	quarts	0.97	liters	l
gal	gallons	3.8	liters	l
cu ft	cubic feet	0.03	cubic meters	m ³
yd ³	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

When You Know	Multiply by	To Find	Symbol
LENGTH			
millimeters	0.04	inches	in
centimeters	0.4	inches	in
meters	3.3	feet	ft
kilometers	1.1	miles	mi
	0.6	miles	mi
AREA			
square centimeters	0.16	square inches	in ²
square meters	1.2	square yards	yd ²
square kilometers	0.4	square miles	mi ²
hectares (10,000 m ²)	2.5	acres	ac
MASS (weight)			
grams	0.035	ounces	oz
kilograms	2.2	pounds	lb
tonnes (1000 kg)	1.1	short tons	ton
VOLUME			
milliliters	0.03	fluid ounces	fl oz
liters	2.1	pints	pt
liters	1.06	quarts	qt
liters	0.26	gallons	gal
cubic meters	36	cubic feet	cu ft
cubic meters	1.3	cubic yards	yd ³

TEMPERATURE (exact)

°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F
-40			-40	
-20			-4	
0			32	
20			68	
37			98.6	
60			140	
80			176	
100			212	

*1 in = 2.54 (exactly). For other units of conversion, and more detailed tables, see FEDS Bk. Publ. 286, Units of Weight and Measure, Price \$2.25, SO Catalog No. C13.10.286.

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1.0 GENERAL INFORMATION

1.1 Introduction

The United States Coast Guard has been tasked, under law, with providing Search and Rescue (SAR) services to people and property in peril on the high seas or in waters subject to the jurisdiction of the United States. This mission entails a large expenditure of manpower and equipment to meet the growing demands for service. Management of the SAR resources is becoming increasingly difficult as the system becomes more complex. SAR managers are tasked with the problem of meeting demands in an effective and economical manner without sacrificing the quality of services rendered.

The management of the SAR system requires that frequent consideration be given to:

- a. Funding justification
- b. Manning levels
- c. Reducing operating costs
- d. Selection of replacement equipment
- e. Fluctuations in demands for services
- f. Operational policies which directly affect resource utilization

SAR management problems are, in essence, concerned with allocation of limited resources with the goal of achieving desired levels and standards of performance. Thus, decisions may be required with regard to:

- a. Establishment, relocation, or disestablishment of shore stations or air stations
- b. Relocation of resources or changes in the mix of available resources
- c. Changes in manning levels
- d. Introduction of resources as replacement, or in addition to existing resources
- e. Actions in anticipation of significant changes in demands for services
- f. Operational policies which directly affect resource utilization.

1.2 Background

The Search and Rescue Simulation (SARSIM) was originally developed under a joint effort between the Coast Guard and the National Bureau of Standards between 1968 and 1972. The early version was written in SIMSCRIPT I.5. It was used operationally by planners at Coast Guard Headquarters from 1972 until 1975. During this period, the Coast Guard Research and Development Center (R&DC) at Groton, Connecticut, used SARSIM in several projects involving resource evaluation. In September 1975, the R&DC was tasked with a project to update and modify SARSIM. Early project work was done on a UNIVAC 1108 at the Naval Underwater Systems Center and then shifted to Control Data Corporation, CYBERNET, in late 1977. The new version is written in SIMSCRIPT II.5. SARSIM is currently being used at Coast Guard Headquarters in Washington, DC.

1.3 The Search And Rescue Process

In order to meet the needs of persons and property requiring search and rescue, the U.S. Coast Guard establishes stations and resources at strategic locations along the coasts and in certain rivers/lakes of the continental United States, Hawaii, and Alaska. In 1977, the inventory of resources consisted of 201 SAR stations, 26 air stations, 1900 boats, 142 cutters, 147 aircraft, and 11,369 military personnel. These units responded to over 74,000 distress calls; directly saving the lives of nearly 4,200 persons, and assisting property valued at over \$2.9 billion. Additionally, assistance was rendered to over 182,000 persons in non-severe situations. This caseload is increasing at about 6 percent per year.

Typical SAR cases evolve in the following manner:

- a. The U.S. Coast Guard receives information that someone is in distress or needs assistance.
- b. The requirements of the case, including weather conditions, type of unit in distress, location, types of service needed, etc., are evaluated.
- c. From the inventory of nearby resources, one or more available and capable resources are dispatched.
- d. If resources are not immediately available, the case may have to be queued until resources can be dispatched or resources are interrupted from other, less severe, cases and diverted to the new case.
- e. Some cases require searching before assistance can begin. Many cases require towing after assistance has been rendered.
- f. Upon completion of the case, resources return to their home stations to become available for other cases, or go directly to another case.

1.4 Overview Of The Simulation

The Search and Rescue Simulation (SARSIM) is a management tool that has been developed to aid Coast Guard decision-makers in developing long-range strategic plans to carry out the SAR mission. SARSIM is a discrete event digital computer simulation program programmed in SIMSCRIPT II.5. It is a highly flexible user-oriented model that simulates Coast Guard response to futuristic caseloads.

In simplest terms, the search and rescue model exemplifies a typical waiting line problem wherein customers, i.e., cases requiring Coast Guard services, enter the system at random times to be serviced by one or more facilities, i.e., Coast Guard resources. A customer being serviced ties up one or more servicing facilities for an amount of time dependent on the location of the case and the type and amount of service required. Accordingly, new customers may arrive in the system and have to wait (in a queue) until an appropriate facility is released on completing its last service or, perhaps, priorities may require breaking off service in progress,

putting the less serious case into a queue. On the one hand, the desire to satisfy "customers" might occasion the acquisition of enough service facilities to keep queuing and waiting time to a minimum. However, it might be considered unacceptable if expensive facilities were maintained in a standby, but idle, condition to achieve the aforementioned objective. Central to this problem, moreover, is the random nature of the arrivals and servicing, hence the need to balance requirements for long-term satisfaction of needs with the possibility of temporary overloading of the system during peak periods or unusual circumstances.

The simulation is keyed to specific events, such as the arrival of cases requiring service, assignment of resources to these cases, interruption of service by an assigned resource which must be reassigned to a case of greater severity, completion of service by one or more assigned resources, handoff of a tow, recall of crews, etc. Consequently, operation of the program proceeds from one significant event to the next, with an internal (simulated) clock keeping track of the simulated passage of time. Thus the simulation allows time to be compressed and a month of cases can be processed in a few minutes on the computer.

SARSIM is comprised of three major modules. The first major module is the PREPROCESSOR. The PREPROCESSOR is used to generate expected caseloads based on the historical SAR Data Base. In other words, it supplies a scenario, or futuristic caseload which may, if desired, be used for many different simulation runs.

The heart of SARSIM, the SIMULATOR, is essentially a bookkeeping system which logs in cases, registers their needs, investigates the availability of service facilities, assigns resources for servicing, and generally keeps track of simulated time spent in the several possible activities represented within the model and maintains statistics for output.

The POSTPROCESSOR is a data retrieval package, which operates on data files from the SIMULATOR to permit a more detailed analysis of simulation runs as a supplement to the printed report from the SIMULATOR.

2.0 THE PREPROCESSOR

The preprocessing of the data in the SAR Data Base to generate futuristic caseloads is accomplished in four phases. Phase 1 selects from the SAR Data Base those elements of each SAR record which will be of use in subsequent processing. Phase 2 creates data tapes which will serve as input for the Phase 3 processing. Phase 3 consolidates cases, classifies cases, and gathers basic statistics to be used in Phase 4. Phase 4 creates futuristic case files which serve as input to the SIMULATOR.

2.1 Phase 1 - SAR Data Base Processing

The raw data base for SARSIM is the SAR data base maintained by Commandant (G-OSR). These coded data are extracted from SAR Assistance Reports (CG-3272 and CG-3272A) which are filed for each SAR case which is prosecuted by the Coast Guard. A sample Assistance Report from CG-397, Search and Rescue Reports Manual (Reference 3) is included as Figure 2.1.1.

The basis for selecting data as input to this version of SARSIM was the National Bureau of Standards model, Reference 1, Volume II. No attempt has been made to do a serious data analysis of the SAR data base to determine what elements of the data base are highly correlated and thus redundant.

Figure 2.1.2 shows the elements in a record of the SAR data base, also indicated are those elements which are selected for input into Phase 2. The data for Phase 2 are abstracted from the "sixteen" file of the Master SAR Data Base File which is organized by district/area and OPFAC. One fiscal year of data is processed at a time. The data processing is accomplished via a UT-14 program, which is submitted by the SAR Data Base Coordinator.

The end result of this preliminary processing is a magnetic tape(s) with one fiscal year of data for the entire Coast Guard. The data is sorted by district/area, but it is all in one file.

2.2 Phase 2 - Creation Of Scope Data Tapes

The main purpose of this phase is to copy the file of SAR data from Phase 1, from Coast Guard computer tapes to Cybernet Scope computer tapes, counting the records and placing end-of-file marks between each district/area. This is accomplished through the use of the TRANZ Program. See Reference 11. The output files are passed to Phase 3 for further processing.

2.3 Phase 3 - Case Consolidation And Classification

The main purposes of this phase are case consolidation and case classification. This is accomplished through the use of a computer program called the Data Preparation Member (DPM). See Reference 12. Case consolidation is a fairly complex process and will be discussed in detail below. Cases are classified along three dimensions: search versus nonsearch; peak versus offpeak; and weekday versus weekend.

Classification of a case as a search case is a straightforward process. All of the demand for service codes (C.08 and C.09 defined in Reference 3) on a case are examined and if the C.08 equals 1, 2, or 3, or C.09 equals 1 or 2, then the case is classified as a search case. Search cases are separated from nonsearch cases due to qualitative differences in the processing of the two types of cases in the SIMULATOR.

The peak/offpeak division of cases is at the SARSIM analyst's discretion, i.e., the analyst defines peak and offpeak periods. The distinction is desirable because of the rather dramatic change in case volume which occurs in peak periods.

The weekday/weekend classification is also based on case volume, with volume being significantly greater on weekends, which are defined as Saturdays, Sundays, and holidays.

In the SAR data base, every unit that responded to a case files a report which becomes a sortie record in the SAR data base. If only one unit responds to a case, then only one sortie record exists in the data base, but if more than one unit responds, things get more complicated, especially since there are several types of multi-unit cases.

Basically, the DPM wants to find all the sorties associated with a case, set background case parameters, such as weather, case location, etc., and, most important, come up with a list of the demands for service (Codes C.08 and C.09 in Reference 3) with which the responding unit(s) dealt. Figure 2.3.1 shows the case characteristics which are set in the DPM.

For the actual consolidation process, the record code is used extensively. It is first used to determine what kind of case we are dealing with and then it is used for the processing of the sorties. There are four kinds of cases: (1) single-station, single-sortie; (2) single-station, multi-sortie; (3) multi-station; and (4) area. Single-station cases have a header record code equal to 3, and if the number of sorties is greater than 1, it is a single-station multi-sortie case, otherwise it is a single-station, single-sortie case. On a single-station, multi-sortie case, all the subsequent sorties have a record code equal to 10, and to make certain that only the sorties for this case are processed, the unit case number is checked for all sorties. The number of sorties code is not used to check for the number of sorties because of the possibility of the omission of some sortie records from the data. For multi-station and area cases there is no header as such in the data file which is being input; however, the record code for the first sortie in these cases is equal to 4 or 5. Subsequent sorties for a given station have record code equal to 10 or 11, then the next stations first sortie record again has a record code of 4 or 5, with the sortie having a record code of 10 or 11. To insure that two multi-station or area cases which occur together in the data are actually separated in processing, the multi-unit case number is checked for each sortie processed.

The nature of the simulation process requires that the system to be simulated be simplified, what this means is that certain real-world situations or data may have to be omitted from the simulation. In performing the case

consolidation process, the DPM also screens the data to insure that only useful data is passed to the next phase. Sortie records, and in certain instances, whole cases may be deleted from the data base. The reasons for sortie/case deletion are described below.

One of the first constraints placed on the data is that the cases all occur in the geographical area of interest. This area is specified by the user in two ways. The first way is by selecting the districts/areas to be processed. The second way is by specifying a geographical area such that cases outside of this area are excluded from consideration.

Next, cases are screened to see if the assisting resource, which responded to the case (C.01 codes in Reference 3), is one which the user has designated as one which will be simulated. If it is not, then the sortie for that resource is deleted and if all the sorties on a case are deleted, then so obviously is the case, since the demands for service are obtained from the sortie records. Examples of the types of assisting resources which might not be simulated are land vehicles (Code 00) and auxiliary (Code 90).

One type of case which is not simulated is one in which two distressed units are aided simultaneously. This type of case has a record code of 20 and all cases with this record code are omitted from consideration.

Another reason for case deletion is if there are too many sorties on a case. The number of sorties which is considered too many is set by the analyst. The basic reason for deleting these cases is that they occur very infrequently and thus, if one occurred during a given run of the SIMULATOR, it could bias the results.

Determination of the number of sorties on a case is a complicated process in that it is different depending on whether we have a single-station or multi-station case. For single-station cases, if the number of sorties given in the header record is greater than 1, then we have a multi-sortie case. Further, it is expected that the record after the header will be a sortie record for the case we are processing, with a record code of 10 and the same unit case number as the header. If it is not, then the case is deleted. If it is, then all sorties with a record code of 10 and the same unit case number are processed and counted.

For multi-station cases, the sorties are determined by an examination of multi-unit case number and all sorties with this case number are included in the case. Again, if too many sorties are encountered, the entire case is deleted.

The remainder of the processing of multi-station/area cases is complicated in that the particular SAR data file we are using has no header records and, even if it did, these would be of questionable value since they would contain optimized data for the case. This optimized data would be for the most effective resource on the case and not necessarily for the first resource dispatched. As far as the simulator is concerned, it is essential that we know the time at which the first facility on the case was notified.

We would also like the weather conditions for the case to be the worst encountered by any resource on the case. The location of the case should be as good as possible and it is felt that the last resource on the case probably has the best idea of where the case actually occurred. The point is that data must be gathered from various sorties which constitute a multi-station case.

Cases are sub-classified as routine or severe, this is accomplished by examining the severity of distress-personnel code, 8.09 (in Reference 3), and the severity of distress-property code, 8.10 (in Reference 3). If the personnel code is equal to 2 or 3, and/or the property code is equal to 3, then the case is classified as severe, otherwise the case is considered routine.

Timing on a case, which was alluded to above, is important in several of the calculations to be detailed below and a complicated algorithm is employed to insure that the times (notified, underway, on scene) on a case are consistent. For details of this algorithm, see Reference 12, Page 22. Basically, the algorithm insures that the time notified precedes the time underway and that the time underway precedes the time on scene with the time notified being accepted apriori as correct.

Demands for service (C.08 and C.09 codes) are entered as a pair on a sortie record. There are some 20-C.08 codes and 34-C.09 codes which means 680 possible demand pairs but only about 150 show up in a typical DPM run with only the first 20 or so pairs having a significant frequency of occurrence. Air escort, stoodby, and air escort are created in the DPM to preserve the fact that these were responded to by an aircraft and that is why there are 34 instead of 32 property demands (C.09). What is desired here is some way of ascertaining the average service time and standard deviation for the more important demands. So for each demand pair type which occurs in the DPM data, a service time for the demand pair is calculated by assuming that transit time to return from the case is equal to the transit time enroute to the case, thus service time for a demand pair is equal to total time on sortie (C.07) minus twice the transit time (time on scene - time underway). The validity of the twice the transit time assumption has not been verified to the author's knowledge. The program keeps running totals of the service times and frequency of occurrence of the various demand pairs and as part of an output report displays the mean service time and standard deviation for each demand pair which was encountered in the data.

The data which is input to the DPM can be up to three fiscal years of SAR data from one or two districts and an area. In larger districts, like District 3, only two years of data can be input at present due to a core memory shortage in the computer system on which the model is presently installed.

Timing information is also used for calculation of total search time on a case which is the sum of the service times for all resources involved in a search. Search time for a resource is considered to be the total service time for that resource on a sortie. Thus total search time includes not only time spent searching but the actual service time of any demands serviced which is an overestimate but it was decided by G-OSR that this would not result in significantly elevated response times in the SIMULATOR.

Total search time is used to calculate total search miles for a case which is obtained by adding together the product of total search time and search speed for each resource on a case. Note that it is assumed that a linear mile traveled by one type of resource is equal (in search area coverage) to a linear mile for another type of resource, which is generally consistent with the SAR Manual sweepwidth tables and overall purpose of Sarsim.

The final function of the DPM is to calculate an occurrence-per-day histogram for each time period and search/nonsearch, weekday/weekend, classification of cases. An occurrence-per-day histogram can be thought of as a table with pairs of entries. The first entry of a pair is an integer, say J , and represents an exact number of cases which occur on a given day. The second number of the pair (P_J) is the probability that exactly J cases will occur on any given day in a particular period of time. To calculate the probability, P_J , of J cases occurring on a given day, it is necessary to know two things: (1) the number, K_J , of days in the period of time being considered which had exactly J cases occur and (2) the total number, N , of days in the period of time being considered. The calculation of P_J is then straightforward: $P_J = K_J/N$ and the table entry is the pair (J, P_J). Note: The summation of the K_J 's from $J=0$ to M is equal to N , where M is the maximum number of cases which occurred on any day within the period of time being considered and

$$\sum_{J=0}^M P_J = 1$$

The occurrence-per-day histograms are used in the OEM to determine the number of cases to select on any given day. This is described further in the next phase (Section 2.4).

For output, the DPM produces a printed report and ten mass storage files which are placed on magnetic tape. The printed report summarizes the reasons for sortie or case deletion (discussed above); displays the number and kinds of good cases written; presents an exhaustive list of the demand pairs (discussed above) encountered, their frequency, mean service time, and standard deviation; finally, several tables displaying the distributions of various case parameters are given.

The case parameter distributions displayed include: geographical area, seastate, visibility, distance offshore, tonnage, demands for service, demand by seastate, and demand by patron. These distributions are all presented for peak-offpeak, search-nonsearch, and severe-routine categories.

The ten files are divided into two sets of five files, one set is for peak period cases and the other set is for offpeak period cases. Each set consists of two keycode files, one for search and one for nonsearch cases; two case files, again, one for search and one for nonsearch; and a statistics file.

The keycode files are used in the next phase to reduce the number of I/O operations in the case selection process. The case files preserve all the details of a case. The statistics file transfers basic initializing information, which includes the occurrence-per-day histograms discussed above.

2.4 Phase 4 - Creation Of Futuristic Case Files

The main purpose of this phase is to produce event files which will be used as input to the SIMULATOR. This is accomplished through the use of a computer program called the Originate Events Member (OEM). The major characteristics of the search and nonsearch event files which are created by the OEM are specified by the SARSIM analyst. The characteristics which can be manipulated include: number of days to be simulated; overall caseload; the mix of distressed units; the distance offshore in which cases occur; alteration of case occurrence in a particular area; specification of demand types; and modification of demand types in a particular area.

The goal of the OEM in the default mode is to produce event files of SAR cases in which all basic SAR population characteristics are replicated. This goal is accomplished via a random selection process among the several years of case data which is used as input to the OEM.

The input data as explained in Section 2.3 is divided into peak versus offpeak, search versus nonsearch, and weekday versus weekend/holiday categories. A given run of the OEM would involve either peak or offpeak cases in the remaining four categories. Search and nonsearch cases are processed separately but in an analogous fashion, therefore, only the processing of nonsearch cases will be described here.

The basic problem is to select say 30 days of representative cases. This is accomplished utilizing the occurrence-per-day histograms discussed in Section 2.3. Case selection is accomplished on a daily basis and the number of cases to select on any given day is resolved by random selection in the occurrence-per-day histogram which is appropriate for the kind (weekday/weekend) of day for which cases are to be selected. Basically, the occurrence-per-day histogram allows between 0 and M cases to happen on any given day where M is the maximum number of cases which occurred on any given day of the type (weekday/weekend) which we are considering. For each number of cases which can occur, a probability has been determined as explained in Section 2.3 and from these probabilities a cumulative probability distribution has been calculated. The cumulative distribution has probabilities ranging from 0 to 1, thus for each number of cases from 0 to M which can occur, there is a probability band associated with it and by entering the probability distribution with an uniform (0,1) random number, a number of cases to select for the day can be determined. This method of determining the number of cases to select on a day, preserves the natural variability in case occurrence which occurs from day to day.

Once the number of cases to select has been determined, then that number of cases is selected randomly and with replacement from the pool of cases of that type, e.g., peak, nonsearch, weekday cases. This random selection process should replicate the distributions of all of the basic case

parameters, and in fact, the distributions for location, type of distressed unit, seastate, visibility, distance offshore, tonnage of distressed unit, and demands for service have been verified; see Reference 15. The time of day at which cases occur is kept with the cases, this was done so that no analysis of case type by time of day would be necessary.

Once a case has been selected, certain characteristics of the case are obtained directly from the DPM-created case file and other characteristics represent modification or additions to that basic data. Figure 2.4.1 shows all the items which make up a case in the event file; there are slight differences between the search and nonsearch files and these are indicated, also indicated are those items which were modified. The items which must be modified or added are of three sorts: (1) items which were coded in the SAR data base and must be converted to real values; (2) the total number of demands is to be reduced and, therefore, a conversion process must be carried out; (3) service times for demands for service are also assigned in the OEM.

The uncoding of coded items is straightforward and virtually identical for all coded items. The items which must be uncoded include: seastate, wind speed, visibility, distance offshore, and tonnage. Let us examine the conversion of a typical code to a real value. Each code value, except for the unknown code, represents a range or class of real values which the characteristic in question may take on and since there is no information available about the distribution of real values within a class, a uniform distribution is assumed and assignments of real values are made accordingly. Thus, if for a code value of "6," the range of real values is "24" to "36" then a value of between "24" and "36" is selected utilizing a uniform distribution. Table 2.4.1 shows the code and class values for each of the variables listed above.

The tonnage variable deserves special mention as it is actually derived from the length of distressed unit code, 8.19, in Reference 3. The length code is first converted to a length in the usual way and then a formula is used to convert the length to a tonnage, namely tonnage equals length cubed divided by 6400.

The unknown codes for all variables are assigned a code value based on the frequency of occurrence of each of the remaining code values for the variable, i.e., the distribution of codes which have known real values is determined by the SARSIM analyst, input to the OEM, and when the unknown code occurs, a new code value is assigned utilizing a uniform (0,1) random number and the analyst-defined distribution. Thus unknowns are redistributed among the known codes, preserving the distribution of known codes.

The demand for service codes (C.08 and C.09) are reduced to a realistic level through the efforts of the SARSIM analyst. The analyst supplies the conversion scheme at OEM run time. For details of the specification process, the interested reader should consult Reference 10 and/or Reference 13.

The assignment of service times is based on the SARSIM analyst's supplied means and standard deviations for each of the demands requiring a service time. Some demands such as "tow" do not require a service time

because the service time for a "tow" is determined by the SIMULATOR. When a service time is needed, the gamma distribution is sampled, utilizing the mean and standard deviation supplied by the analyst.

The remaining items which need to be discussed regarding processing in the OEM are concerned with those characteristics of a caseload which can be altered by the SARSIM analyst. Items included here are increase or decrease in the overall caseload, alteration of the distribution of distressed units in the overall caseload, imposition of a distance offshore band for cases, adding or deleting cases in a particular area, and alteration of the demand mix in an area.

The SARSIM analyst, in order to present a realistic caseload to the simulator, may want to either increase or decrease the overall caseload. This is accomplished by specifying the percentage increase or decrease and then this increase/decrease is applied to the number of cases which are to be selected daily. The user may specify different percentages for search or nonsearch and weekday or weekend/holiday cases.

If desired, the analyst may specify the mix of distressed units, this mix would apply to the total caseload and is imposed after the increase/decrease has been applied. The mix is specified simply by listing distressed unit codes and the percentage of that code which is to be selected.

The distance offshore restriction is imposed after basic case selection has taken place and involves the deleting of cases which do not satisfy the analyst's distance offshore restriction. Both an upper and a lower bound may be specified for the distance offshore restrictions.

The analyst may desire to add cases in one area and delete cases in another area. For instance, if a new marina opens, cases may need to be added, and if a marina closes, cases may need to be deleted. The addition of cases is accomplished by having the analyst specify an area and an occurrence-per-day histogram for that area, additionally a distribution of distressed units may also be included. These cases are simply added to those already selected. The deletion of cases in an area is accomplished by either specifying a percentage of cases which are to be retained in the area or by specifying a percentage of particular distressed unit types which will be retained. Distressed unit types which are not specified will not be affected.

The alteration of the demand for service mix in an area is accomplished by specifying the demands to be altered and their probability of retention if encountered. The analyst might wish to alter the demand mix if, for instance, a new towing service opened in the area and it was expected that the number of "tow" demands should be reduced.

Finally, since all case selection is based on random processes, the analyst is allowed to request several sets of cases for the period to be simulated and final selection of the event files to be used as input to the simulator would then be from among these several requested sets.

<u>ELEMENT NUMBER</u>	<u>CONTENT</u>	<u>KEPT FOR PHASE 2</u>	<u>REMARKS: ITEM NUMBER IN CG-397</u>
1	District number	*	
2	Multi-unit case number	*	A.02
3	District number		
4	Single-unit OPFAC number	*	A.01
5	Unit case number	*	A.03
6	Record code	*	
7	Record number		
8	Unit name		
9	Month notified	*	A.04
10	Year notified	*	A.04
11	Total number of sorties on case	*	A.05
12	Day of the month notified	*	8.01
13	Hour of the day notified	*	8.01
14	Minute of hour notified	*	8.01
15	Time from occurrence to notification		8.02
16	Means of initial CG notification		8.03
17	Nature of distress		8.04
18	Distance offshore code	*	8.05
19	Latitude in degrees	*	8.06
20	Minutes of latitude	*	8.06
21	Longitude in degrees	*	8.07
22	Minutes of longitude	*	8.07
23	Method of locating distressed unit		8.08
24	Severity of distress - personnel	*	8.09
25	Severity of distress - property	*	8.10
26	Cause of distress		8.11
27	Sea state	*	8.12
28	Wind	*	8.13
29	Visibility	*	8.14
30	Type of distressed unit		8.15
31	Ownership of distressed unit		8.16
32	Usage of distressed unit	*	8.17
33	Propulsion of distressed unit		8.18
34	Length of distressed unit	*	8.19
35	Gross tonnage distressed unit		8.20
36	Official/Registration number		8.21
37	Number of lives lost	*	8.22
38	Number of lives saved	*	8.23
39	Number of persons otherwise assisted	*	8.24

FIGURE 2.1.2

ELEMENTS OF A SAR DATA BASE RECORD

<u>ELEMENT NUMBER</u>	<u>CONTENT</u>	<u>KEPT FOR PHASE 2</u>	<u>REMARKS: ITEM NUMBER IN CG-397</u>
40	Value of property assisted	*	B.25
41	Day of week		
42	Day/Night		
43	Type of assisting resource		C.01) These data
44	Distance to scene or search area		C.06) are optimized
45	Assistance rendered to personnel		C.08) for this
46	Assistance rendered to property		C.09) case
47	Type of assisting resource	*	C.01
48	Assisting resource number		C.02
49	Day of the month underway	*	C.03
50	Hour of the day underway	*	C.03
51	Minute of the hour underway	*	C.03
52	Number of remaining resources on standby		C.04
53	Day of the month on scene	*	C.05
54	Hour of the day on scene	*	C.05
55	Minute of the hour on scene	*	C.05
56	Distance to scene or search area		C.06
57	Total time on sortie (hours)	*	C.07
58	Total time on sortie (tenths of hours)	*	C.07
59	Assistance rendered to personnel	*	C.08
60	Assistance rendered to property	*	C.09
61	Performance index		C.10

NOTE: Please consult Reference 3 for complete details on the items mentioned above.

FIGURE 2.1.2 (continued)
ELEMENTS OF A SAR DATA BASE RECORD

<u>VARIABLE</u>	<u>HOW OBTAINED</u>
Hour of occurrence	T
Minute of hour	T
Longitude (radians)	C
Latitude (radians)	C
Sea state code	T
Wind code	T
Visibility code	T
Severity (severe or routine)	C
Distance offshore code	T
Usage of distressed unit code	T
Number of lives lost	T
Number of lives saved	T
Number of persons otherwise assisted	T
Value of property assisted	T
Number of demand pairs	C
(Assistance rendered to personnel code	T#
(Assistance rendered to property code	T#
(Number of miles traveled until sortie aborted	T#
Additional variables for search cases	
(Day of month notified	T
(Total miles searched	C

C = Calculated Variable
T = Transferred Variable

indicates a variable which is repeated for each set of demand pairs

FIGURE 2.3.1
TYPICAL PHASE 3 CASE RECORD

<u>VARIABLE</u>	<u>HOW OBTAINED</u>
Name of event ("NOSRCH" - nonsearch; "ENIGMA" - search)	C
Time of occurrence	C
Sea state	C
Wind	C
Visibility	C
Severity	T
Longitude	T or C
Latitude	T or C
Distance offshore	C
Usage of distressed unit	T
Tonnage of distressed unit	C
Number of lives lost	T
Number of lives saved	T
Number of persons otherwise assisted	T
Value of property assisted	T
Number of demands for service	C
Name of demand	C#
Service time for the demand	C#
Additional of variables for search cases	
Total miles searched	T
Hour of occurrence	T

C = Calculated Variable
T = Transferred Variable

indicates a variable which is repeated for each set of demand pairs

FIGURE 2.4.1
TYPICAL EVENT FILE CASE RECORD

TABLE 2.4.1

CODED VARIABLES WHICH ARE GIVEN REAL VALUES

<u>VARIABLE</u>	<u>CODED VALUE</u>	<u>REAL VALUES IN CG-397</u>	<u>VALUE ASSIGNED BY SARSIM</u>
SEA STATE	0	Calm (feet)	0 (feet)
	1	1 - 2	1 - 2
	2	3 - 4	3 - 4
	3	5 - 6	5 - 6
	4	7 - 10	7 - 10
	5	11 - 20	11 - 20
	6	Greater than 20	20 - 50*
	8	Land	0*
	9	Unknown	0 - 50
WIND	0	Calm (knots)	0 (knots)
	1	0.1 - 10.0	0.1 - 10.0
	2	10.1 - 20.0	10.1 - 20.0
	3	20.1 - 30.0	20.1 - 30.0
	4	30.1 - 40.0	30.1 - 40.0
	5	40.1 - 50.0	40.1 - 50.0
	6	50.1 - 60.0	50.1 - 60.0
	7	60.1 - 70.0	60.1 - 70.0
	8	Over 70	70.1 - 100.0*
	9	Unknown	0 - 100
VISIBILITY	0	0 - 1/4 (miles)	0 - 1/4 (miles)
	1	1/4 - 1/2	1/4 - 1/2
	2	1/2 - 1	1/2 - 1
	3	1.1 - 3.0	1.1 - 3.0
	4	3.1 - 5.0	3.1 - 5.0
	5	5.1 - 10.0	5.1 - 10.0
	6	10.1 - 15.0	10.1 - 15.0
	7	15.1 - 20.0	15.1 - 20.0
	8	Unlimited	20.0*
	9	Unknown	0 - 20
LENGTH TONNAGE (#)	0	Other than vessel	0 (feet)
	1	Less than 16 feet	5 - 16
	2	16 - 26 (feet)	16 - 26
	3	26 - 40	26 - 40
	4	40 - 65	40 - 65
	5	65 - 100	65 - 100
	6	100 - 200	100 - 200
	7	200 - 300	200 - 300
	8	300	300 - 1200*
	9	Unknown	0 - 1200

* Extreme values were established by G-OSR

TONNAGE = (LENGTH)³/6400

TABLE 2.4.1 (continued)

CODED VARIABLES WHICH ARE GIVEN REAL VALUES

<u>VARIABLE</u>	<u>CODED VALUE</u>	<u>REAL VALUES IN CG-397</u>	<u>VALUE ASSIGNED BY SRSIM</u>
DISTANCE	0	Land	0 (miles)
OFFSHORE	1	0 - 3	0 - 3
	2	3.1 - 10.0	3.1 - 10.0
	3	10.1 - 25.0	10.1 - 25.0
	4	25.1 - 50.0	25.1 - 50.0
	5	50.1 - 100.0	50.1 - 100.0
	6	100.1 - 150.0	100.1 - 150.0
	7	150.1 - 300.0	150.1 - 300.0
	8	300	300 - 1100*
	9	Unknown	0 - 1100

* Extreme values were established by G-QSR

TONNAGE = (LENGTH)³/6400

3.0 THE SIMULATOR

3.1 SIMULATOR INTRODUCTION

In terms of Queueing theory, the SIMULATOR is a multi-server, priority discipline model with ill-defined arrival time distributions, which in effect simulates the SAR system by setting up an appropriate mathematical model that relates the component quantities: Coast Guard vehicles and service facilities. The SIMULATOR is a computer model that combines historical data and event-paced simulation for the purpose of evaluating and predicting the behavior of these components. Having observed the manner in which the system behaves over a time period under such simulated conditions, the system may be altered in an attempt at improvement. Artificial system histories can be constructed and averaged in order to obtain estimates of system performance and suggestions for possible improvements to the SAR system.

The OEM output provides the stimulus necessary to activate the simulator's response mechanisms. This output is in the form of reported historical Coast Guard Cases as outlined in Section 2.0. The reported Case's parameters include information about the time of occurrence, the location, the environment, and reported demands for service. Responding resource data for a sortie is not included as input to the SIMULATOR. This is because forcing the same resources and/or stations to respond to a call for service that were assigned to the Case historically would defeat the purpose of exercising the model which is to be able to allocate different resources and/or stations in order to ascertain the consequences that this has on SAR effectiveness. Thus the SIMULATOR's responses are independent of historical sortie response.

As the Cases are presented to the SIMULATOR, the time of notification on the Case Record produces a time series which is assumed to be a true realization from the collection of all possible sample functions which the random phenomena might have produced in the real SAR world. A multidimensional vector of Case attributes is associated with each of these times of notifications. The vector contains parameters characterizing the nature of the distress and the environment.

Only two variables reflect the environment; visibility, (in miles), and sea state, (in feet). Although these variables vary as each Case enters the SIMULATOR, they remain constant during the time that the Case is being processed.

The parameters describing the nature of the distress are limited to the demands for service and the tonnage of the distressed unit or client. The tonnage is used for selecting an able resource or responder to the client. The type of client has no effect on the response of the system.

The service requirements or demands are assumed known at the time of notification if the Case is not a search. The resource that is ordered to service the client is assigned demand(s) prior to departing its station.

The priority of the Case has the greatest effect on the response mechanisms of the SIMULATOR. The SIMULATOR reacts to a binary condition of either severe or routine. Analyst controlled selection policies for both stations and responders elicit a variety of alterations in the way in which the Cases are handled by the system. Although the parameter that initially contains the priority's status does not vary during the time that the case is being processed, the technique of queueing Cases FIFO produces an increasing priority queue discipline!

The reported positions of the clientage are assumed fixed throughout the duration of Case processing. This location greatly influences the timeliness of providing the services and the manner in which resources are selected because of restrictions imposed by fuel limitations, distance limitations, and the amount of time that a crew can remain aboard a resource.

The SIMULATOR responds to the above stimuli by determining the primary station that is to receive the distress call. The nearest station to the client's reported position is considered to be the primary station.

Each station is assigned a set of resources which can vary by type thereby yielding dissimilar capabilities. Since the resources have physical traits that limit their operation in certain kinds of weather, distance constraints, maintenance downtimes, crew unavailability and inability to service certain demand types, resources affiliated with a station may or may not be able to sortie to the Case. In order to effectuate a response, the SIMULATOR may need to solicit other nearby stations. The aforesaid selection policies will also have an impact on the actions that follow the entrance of a Case into the SIMULATOR.

Resources are central to the model, as they provide the system dynamics through the response given to calls for service, i.e., without resources, no activity would transpire in the SIMULATOR.

When a resource is sent to service a client, the average speed of the resource is most critical in that it directly affects the amount of time that a client will wait for service. Other parameters such as fuel consumption rate, fuel capacity and crew endurance play an important role in servicability. For example, a responder searching for a lost craft may be forced to leave the search area prematurely due to fuel shortage or rules prohibiting the crew from remaining on duty past a given length of time. In addition, the cost/operating hour for a resource can be a factor in selecting a resource for a Case.

Many events are generated throughout a particular exercise. As these events cause interactions within the SIMULATOR many outcomes are possible for specific items of interest. In order to introduce the way the system behaves when supplied with the Case stimulus a few examples are given in Table 3.1.1, SIMULATOR Behavior.

Condition A is an example of a very simple Case in which the client needs a tow. A station is found that has an available qualified resource, resource #1. The Coast Guard was notified of the incident at 0800 hours. During the period from 0800 to 0830, the crew and resource are readied, commencing the journey to the location of the distressed unit at 0830 hours. The trip takes 45 minutes so the rescue vehicle arrives along side the

disabled craft at 0915 hours. Hooking up the tow takes 15 minutes. The resource begins towing the client to the nearest dock at 0930 hours. Finally, the resource releases the unit at another station at 1000 hours arriving back at its home station 30 minutes later. The last column in the table gives a waiting time of 1.25 hours, which is the time from notification until the resource arrived on scene.

Example Condition B introduces the affect of downtime on the SIMULATOR. The Case is identical to the above except that a delay of 30 minutes is added to the departure time of the resource. This causes the waiting time to increase to 1.75 hours. The delay may have been caused by maintenance or perhaps refueling the resource after it had just returned from a previous Case. It is possible that another resource may respond to the Case thereby resulting in the delayed resource not being selected to respond.

More complex activity takes place in example Condition C. Case number 2 enters the system at 0845 hours while resource #1 was enroute to Case number 1. Case number 2's priority is "severe" because there is a fire on the craft. The distressed craft is within range of resource #1. Since case number 1 is "routine", it is preempted and queued at 0850 hours, i.e., the time that resource #1 diverts to Case number 2. Resource #1 arrives along side the burning vessel at 0920 hours and starts fighting the fire.

In the meantime, another resource, #2, completes service on some other nearby Case, (not shown in table), and heads for Case number 1 at 0902 hours. It arrives along side the disabled craft at 0930 hours, hooks up the client and at 0945 hours starts to tow the vessel to the nearest facility.

After the fire is put out on Case number 2, resource #1 heads back to its home station at 1045 hours. If resource #2 hadn't responded to Case number 1, resource #1 would have gone back to the original distress and towed the disabled craft to the nearest dock. This would have resulted in a much longer waiting time for Case number 1.

Example Conditions D and E are searches. In example Condition D a resource #1 arrives in the search area at 1400 hours and spends 3 hours searching for the lost craft. The resource returns home at 1730 hours without finding the distressed unit because it was not able to operate at night.

Example Condition E demonstrates the circumstance where another resource, #2, is sent on the same search case. After searching for about an hour, the resource becomes low on fuel at 1500 hours. The resource leaves the area and transits to a nearby refueling site arriving there at 1520 hours to replenish its supply. This operation takes 35 minutes. At the end of this time the resource returns to the search area at 1615 hours and stays for 2 hours and 15 minutes to complete the search. When the search is finished, additional service may or may not be necessary. If it can't help, resource #2 arrives home at 1901 hours.

A special type of resource called a patrol is allowed to roam about a specified area and may be allowed to participate in servicing a Case or engage in search exercises. In example Condition C, resource #2 could very well have been a patrol type resource.

The analyst should study the above examples and visualize the multitude of activities that responders might well be involved in both the real world and the SIMULATOR.

After the SIMULATOR has processed all the events within the desired time frame, a report is generated with a variety of statistics such as; the number of queued cases, crew and resource utilizations, number of sorties by station and resource type, average transit times, average waiting times, frequency distributions of variables of interest, etc. (See section 3.5)

In addition, data concerning the disposition of each Case are optionally output to a file which is accessible through the use of a data retrieval system. In this way, the analyst can obtain snapshots of certain behavior after the simulation has run its course to gain further insight into the operations being studied. The analyst can also tailor his reports to a specific problem. (See section 4.0)

3.2 SIMULATOR Input

3.2.1 Preparation of Input for the SIMULATOR

The SIMULATOR requires two types of input. The first type consists of the event scenarios that were generated as output of the PREPROCESSOR. The user specifies two case files for input into the SIMULATOR, one file containing search cases and one file containing nonsearch cases. See Reference 13.

The second type of input is the user specified data, which are prepared on computer cards. Table 3.2.1 describes both those data elements that are required as input by the user and those that are available as user options. See Reference 10.

The user control inputs corresponding to Table 3.2.1 are discussed below:

(1) Debugging Flags (Elements 1-5) - Although the user will probably not be concerned with using the debugging tools that are provided for in the SIMULATOR, he must still provide the program with an input indicating whether or not he desires to have the event trace outputs activated. Should the user happen to desire trace output, he must also specify those events for which he desires the output (e.g., arrive scene, arrive home, or end search). Additionally, the user is required to specify whether or not he desires particular trace types, where the types include search, nonsearch, and underway traces, regardless of his decision for the event traces. Set elements 1-5 to 1 and elements 41-42 to 0.0.

(2) Simulation Time Data (Elements 6-10) - The user is required to specify the number of days he wishes to simulate, the month, day, and year of the start date and the corresponding Julian date. The start date must be on Monday.

(3) Output Options (Elements 11-12) - The user has the ability to specify whether or not he desires the printed output reports which are provided at the end of the simulation run. He also has the option of choosing to collect and record the detailed case data for subsequent postprocessing.

(4) Resource Selection Policies for Routine Cases (Elements 13-14) - Two policies must be specified by the user so that the SIMULATOR can determine the resource selection for routine cases. The two policies are an economic and the station selection policy, where the priority policy considered by the SIMULATOR is the station selection policy. That is, the SIMULATOR first determines the desired station and/or stations from where a resource may be selected according to the specified policy and then selects the resource from the selected station(s) based on the chosen economic policy. The station selection policy affords the user with four options, including selection from the nearest station only, the nearest station within the nearest group only, the nearest station and its adjacent station, and the nearest station with an available resource. The economic policy also affords the user with four options. That is, once the possible station(s) has (have) been determined, the SIMULATOR selects resources based on a minimum weighted ranking, minimum costs, fastest to arrive on scene, or alternatively with no consideration given to speed or cost.

(5) Resource Selection Policies For Severe Cases (Elements 15-16) - Two policies must be specified for severe cases. These policies include the station policy and the interruption or preemption policy. The first policy affords the user with two choices; resource selection is made either from among the stations within the nearest group or alternatively from any station that has an available resource. The second policy specifies the priority for resource selection when interruptions of underways may also be considered. This policy allows the user four options. The first option specifies that interruptions are not allowed, i.e., resources that are enroute to a case, servicing, returning home, or patrolling cannot be considered for selection. The second option specifies that resources will first be selected from underways and then, if necessary, from resources located at facilities. The third option specifies that the resources will be selected from those stationed at facilities and then, if necessary, from those that are underway. The last option allows for resource selection from either facility resources or underways with no regard for a specified order in the selection.

(6) Crew Change Policy (Elements 17, 32, 33, 105 and 106) - The actual number of personnel making up the crew is immaterial to the SIMULATOR. Furthermore, a crew is not assigned to any particular boat or aircraft. The analyst can control the shifts that crews are available in the following ways:

1. Ready Crews: This type of crew is available throughout the exercise. Although, its selection can be refined by having it available only on weekends or weekdays, it will be ready at any hour during a day.

2. Standby Crews: These crews are available throughout the simulation but they have a pre-set time delay which effects the departure time of the resource. The weekday-weekend refinements as described above for the ready crews also hold for the standby crews. However, the SIMULATOR will always try to assign ready crews before standby crews. Also, if a resource with a standby crew has not departed its station and another resource becomes immediately available to perform all the demands that are assigned to the standby crew resource, the standby crew will be recalled and the other resource will take over the Case.

3. Crew Changes: The user is afforded with two methods for specifying crew changes. That is, a crew change may be effected district wide or for each station. However, the user must select one method or the other at the beginning of a run.

In the former instance, the capability to evaluate the effects of varying shore station readiness posture is provided within a 24 hour period. To accomplish this the analyst can input two times, i.e., 0800 and 1600. These would be the times within a 24 hour period when any standby crews would change to ready crews and then back to standby. The weekday-weekend limits will still override this policy. In the latter instance, the analyst can preassign the time the ready crew is to go on and off duty during a shift.

(7) Accompanying Resource Policy (Elements 19-20, 28) - The user also has the option of selecting a forced accompanying resource policy for both search and nonsearch cases. When the user opts for this forced accompaniment at least one surface and one air resource will be sent to the case. If there is no actual demand for the resource to service, a dummy standby demand is created.

HH-52A Policy: A special forced accompaniment is also included in the SIMULATOR in which the HH-52A resource types will never be selected as responders for Cases more than 25 miles off shore without accompanying resource types. This feature is "hard wired" in the SIMULATOR, i.e., the analyst cannot control this policy.

(8) Search Policy (Element 18) - The user has the option of selecting two search policies. The first policy is one where the user specifies the preferred and alternate resources for routine and severe cases separately (elements 77-83). This option also requires the user to specify which resources are preferred to go within and beyond a particular distance. This method is referred to as the SEARCH TABLE policy. The second policy allows for resource selection from available resources and tries to send the same number of resources that participated historically. It is anticipated that since the first method could impose some rather strict limitations that the second method might be the more desirable.

(9) Random Flags (Elements 21-23) - The users also has the option of choosing either random or constant times for the service time, dispatch time, and standby time.

(10) Tow-Handoff Data (Elements 25-27) - The user must specify three parameters for tow-handoffs. They are the minimum distance at which a resource requiring a two-handoff can get to the shoreline, the time it requires for the tow-hookup, and the maximum time that a resource can wait for a tow-handoff.

(11) Standby Service Time (Element 28) - If the user has opted for the forced accompaniment policy he must specify the time that he would like the resource to standby, should this dummy demand be necessitated.

(12) Crew Ready Time (Element 29) - The user must input either a constant or the mean time for readying a standby crew depending on his previous selection.

(13) Fueling Times (Elements 30-31) - Two times must be entered for resource refueling, i.e., the time for resources refueling at any refueling station and the time for home station refueling by any resource.

(14) Districtwide Crew Shift (Elements 32-33) - Should the user select this method for crew shifts, he must provide two other inputs. They are the time which a standby crew shifts to ready status and the time at which the crew shifts back to standby status.

(15) Failure Criteria Times (Elements 34-36) - The user must specify three different times that are used by the simulation program to declare failures. The first of these failures is a response failure, where the elapsed time from the initial notification of the distressed to the arrival of the first responder exceeds the user specified time. The second is a transit failure, where the first responder fails to arrive from its dispatched point within the user specified time. The third is a locate failure, which occurs when the elapsed time from the arrival of the first responder to the designated search area until the search is completed exceeds the user specified time.

(16) Event Flags and Times (Elements 37-40) - The user has the option of activating an event which accumulates statistics at specified intervals of time. If the user desires the event, he must specify a time interval and if he does not, he merely has to input a zero. Since the actual programming of the event code is done by the analyst the user is urged to suppress the triggering of this event. The user also has the option of specifying data for the activation of another event, READI, where this event performs a somewhat more meaningful function. The user first must indicate whether or not he is specifying the time(s) for triggering this event. He then must specify the number of times as well as the actual times that he is providing as input. This event is used for several activities, the primary one being to check to determine if waiting distressed units can be taken out of queue because of new availability of resources at the time provided.

(17) Snapshot Debugging (Elements 41-42) - An option is available for specifying beginning and ending times for which the traces (Elements 1-5) will be activated. However, this option is generally used by the programmer and the user can suppress use of the debugging tool by specifying zero times.

(18) Time Zone (Element 43) - The user must specify the time zone in which the district is located. The time zone is from Greenwich and is necessary for the sunrise and sunset calculations.

(19) Input Printout Flag (Element 44) - The user has the option of having his input data printed out. Selecting this option is generally a good idea in that it provides the user with a means for examining the data and detecting possible errors that were made in the data preparation.

(20) Patrol Option (Element 45) - The user must specify whether he desires to include patrols in the simulation.

(21) Sunrise and Sunset (Elements 46-48) - The user has the option of specifying constant times for the sunrise and sunset or allowing the program to do the calculation. If he chooses constant times, he must specify the desired times of day for these activities.

(22) Figure of Merit (Elements 127-134) - The user must input eight parameter values used in calculating the figure of merit for the exercise. The user is referred to Reference 10 for a discussion of this calculation.

(23) District Numbers (Elements 135-137) - The user must specify the district and/or area numbers that are to be simulated. There is a required format, however, in this case and it is A 4 left justified.

(24) Comments (Elements 139-141) - The user may supply three cards of comments describing the simulation run. These three comments will appear on the printed summary.

The remaining data can be divided into six categories, the resource characteristics, the search resource inputs, the resource allocation data, the patrol data, delay, and demand data. The description of these data is given below.

(1) Resource Characteristics (Elements 49-75) - The user has the ability to specify the operational characteristics of the resources. In order to be able to do this, he must specify both the number of resource categories for which the characteristics are specified and the number of different resource types that are included in the data. The type characteristics that can be specified include a name or other identifier and hourly operating costs. Operational restrictions such as maximum tonnage that can be towed, maximum allowable seastate, minimum visibility and the minimum time to be on scene are user inputs. The user can also specify whether a particular type can operate in day and/or night conditions along with its refueling capabilities. The hourly fuel consumption rate as well as the maximum fuel capacity must be specified for the resource type. Other operational characteristics which are specified include the maximum crew endurance, the maximum allowable distance offshore, and the maximum allowable distance from homeport. The user may also specify demands which cannot be performed by a resource type by indicating the number and name of the demands. The resource category (e.g., boat, cutter, fixed wing aircraft) must be given. There

is a capability for specifying five speeds for each resource type. These speeds include a normal operating speed and both a maximum towing and non-towing speed for seastates less than or equal to five feet and for seastates that are greater than five feet. The user may also specify a search-effectiveness coefficient which corresponds directly to the resource's ability to complete its search.

(2) Search Resources (Elements 77-83) - Should the user choose to specify with the search resources rather than have the program select them, he must specify a SEARCH TABLE with both the number of the preferred and the alternate resources along with the type designator and a search environment code. This environment code specifies the type of cases (routine or severe) that the resource can service and its distance offshore capabilities. If the resource is an alternate, the user must also specify the rank of the alternate, which is used in determining the resource assignments when the preferred are unavailable.

(3) Resource Allocation Data (Elements 84-106) - The intent of these data is to define the groups and stations and the resources provided at each. The user must first specify the total number of groups. Then for each group, he must specify a designator number and the latitude and longitude of the centroid of the group along with the number of stations in the group. For each station, a name, type, and latitude and longitude must be specified. The user then specifies the number of resources, the type name, a reliability parameter indicating the probability that the type is capable of getting underway when it is needed, and an index which indicates its dispatch delay. The total number of crews is specified for each station. For each crew, the status (i.e., weekday and/or weekend availability and ready or standby status) must be specified. Beginning and ending shift times need only be specified if the user has selected the station by station method of crew shifts.

(4) Patrol Data (Elements 107-120) - Patrol activity cycles are independent of normal program activity cycles. This independence is accomplished through the use of a special entity which is used to store space-time information. This information is supplied to the program if the patrol is called upon to service a Case.

The user can control the activity cycles of the patrol by the manner in which he creates the entity and sets the attributes of the entity. In order for the user to understand how to set up the patrols he must be aware of the events from the time that the patrol comes into existence, or is born, until it goes out of existence, or dies. During this process the patrol becomes active either at a home station or at a patrol area, transits to an area, remains in its assigned area for a period of time and returns to its original location where it goes out of existence. These cycles are accomplished through the use of four event notices which have as an attribute the identification number of the entity. They are:

INPATR: This event when triggered brings the patrol in to existence.
ACTPAT: This event is triggered when a patrol arrives at the centroid of the patrol area.

RTNPAT: This event is triggered when the patrol leaves the patrol area.
TERMPA: This event is triggered when a patrol arrives at its home station.

The user will be able to schedule the events INPATR and RTNPAT and by setting the attributes appropriately will be able to control the other two events, ACTPAT and TERMPA, as the simulation proceeds. The event INPATR MUST be scheduled for each patrol in the input parameters, i.e., the user must define the existence of the patrol.

Many combinations for the activity cycles are possible but the following four modes are suggested and are the only ones the user should set up:

MODE 1: Patrol comes into existence at its home station, transits to a specified area, stays in the area for a specified time and then transits back to the home station for termination.

MODE 2: The patrol comes into existence in the area and after a given period of time, which could be the length of the simulation, it terminates.

MODE 3: The patrol comes into existence in the area, stays there for a period of time and then transits back to a home station and terminates.

MODE 4: Same as (a) above except occurring periodically.

The above combinations are accomplished by the user by the order in which the entities are created and by the values that the attributes of the entity are set to as described below:

(Refer to Table 3.2.1 for a description of the attributes below.)

MODE 1: This mode will require two Patrol entities created with the same unique name. The first entity created will have one attribute set to "INPATR" and another attribute set to the time that the user wishes this patrol to come into existence. Total time on patrol must be set to a value greater than the time that the exercise is to end, i.e., a very large value. The second entity will have one attribute set to "RTNPAT" and the other set to the time in hours that the user wishes the patrol to return to station. Note: The user must be aware that the program will calculate the time that the patrol is to arrive at the scene based on the coordinates given by the latitude and longitude of the patrol area and the station, so he must figure this time into the time that he wishes the patrol to begin its return. Another variation of this mode is to let the program schedule the patrol's return to station. This is accomplished by not including the second entity and setting various flags. The user can continue this process for more than one cycle if he is very careful not to let the return times overlap, i.e., make

sure the next INPATR event is scheduled to occur after the patrol returns to station and is terminated.

- MODE 2: As is always the case, the patrol must be initially created with an entity set to "INPATR". Another entity is required with an attribute set to "RTNPAT". Again, as in MODE 1, the total time on patrol in the first entity must be set to a very large value greater than the simulation exercise termination.
- MODE 3: Two entities are required with the first set to "INPATR" and the second set to "RTNPAT". The control flags are set so that the time to leave the patrol area will be calculated. In this case the second patrol entity record is not required and the program will use the total time on patrol to schedule the event "RTNPAT".
- MODE 4. For this mode we only need the initial entity record with an attribute equal to "INPATR". By setting various control flags, the program will evaluate the next time to go on patrol and to schedule the next "INPATR" event. Again the user must be aware that the program will calculate the transit times based on the position attributes of the patrol and must account for these times if he wants the timing to be correct.

The user must include an entity with the same unique name as the patrol in the resource class tables, i.e., the capabilities and limitations must be defined.

The patrol statistics are gathered separately from the normal resources so a special group with number 7777 must be created and filled with stations and resources similarly as with normal processing except that the program will not attempt to select any of these resources. The fictitious stations are only used for collecting statistics. A resource with the same unique name as the patrol must be assigned to the patrol's home station which also must have the same name as the patrol's home station. All station names must be unique, i.e., there must be as many stations in GROUP 7777 as there are patrols.

The user may collocate a patrol's home station with any other station. The patrol's home station may not have the same name as a station in a normal group. In this way the patrol can be sent from his home station but not in the same way as is done in normal processing.

(5) Delay Data (Elements 121-122) - The user must enter delay times for readying a resource, i.e., dispatch delays. He must specify the number of delay times that he wants to enter. If he does not want any delays, he should use zero.

(6) Demand Data (Elements 123-126) - The user must specify the number of demands that can be serviced, name each demand, and give an accompanying rank indicating the resource's order for performance of each demand. Additionally, if the user has selected the random service time option, he must accompany each demand with a mean service time.

3.2.2 Output of the SIMULATOR User Input

The output of the SIMULATOR is of several types, including a printed echo back of the input data, printed trace data, printed summary data, and detailed data which is written to a file for subsequent postprocessing. The printed echo back of the input is a user option. The printed summary data and the detailed data are also user options and are described in Section 3.5. and 4.0. A discussion of the output echoed back is given below.

a. Resource Table. This table lists the resource types which are available for servicing the caseload. It also echos back the characteristic data that the user initially provided. The operational capabilities include the towing limitations, the maximum seastate and the minimum visibility for operations, the crew endurance, and the maximum distance the resource can travel from its homeport to the scene. The economic characteristics include the fuel consumption rate, total fuel capacity, and the hourly operating costs. The night operations code, minimum allowable time an scene, and distance offshore limitations are also shown. A list of those demands which the resource type is not capable of handling is also presented in this table.

b. Resource Allocation Table. For each group defined in the input data, a table is printed depicting the resource allocation at the various stations. Within this table, the group number and latitude and longitude are given. The name of each station in the group is also presented along with its latitude and longitude and type designator (i.e., air or non-air station). The type designator of each resource that is available at each station is then listed. For each type, the quantity, dispatch delay, the hourly operating cost, and the reliability probability are then given.

c. Search Resources. If the user has chosen to specify the resources to be used for search cases rather than allowing the program to do so, then two tables are printed out to echo back the choices. The first table lists only the preferred resources and the second provides a composite of the preferred and alternates. In the second table, the type name, rank and sector codes are given. The sector codes correspond to those specified in the preferred resources only table.

d. Policy Table. The user options for policy selection are also given. The resource selection policies for routine cases, economic and station, are listed in the printed table as ROUTINE ECONOMY and ROUTINE FACILITIES. The resource selection policies for severe cases, interruption and station, follow in the printed table as SEVERE INTERRUPT and SEVERE FACILITIES. The crew change policy and the search resource selection method follow under the titles, CREW and SEARCH, respectively. The nonsearch and search accompaniment policies then follow as NSMIX and SMIX.

e. Dispatch Delays. The dispatch delay times are presented tabularly on the same page as the policy table.

f. Resource Speeds Table. The speeds of the resources are presented tabularly by resource type. The speeds include the maximum operating speed for two seastates (where rough implies greater than 5 feet and

calm is less than or equal to 5 feet), the towing speed for the same two seastates, and the normal operating speed. Additionally, this table includes the search effectiveness coefficient, i.e., where 1 indicates no change and 2 indicates a doubling of the speed so that the search activity is completed twice as fast.

g. Patrol Attributes. The patrol data which is user specified is also echoed back on the output report. These data include the patrol events, names, and the patrol resource name and station. The patrol position (latitude and longitude specified in radians) and the diameter of the coverage area. Both the periodic and initial event times are presented along with the on scene time. The patrolling activity is printed out along with the mechanism for activating the patrol.

h. Crew Table. The last printed table of the input data depicts the crew allocations at each station. The table lists the ready crews and standby crews at each station separately. The status (weekdays, weekends, or weekdays and weekends) and the quantity of each is given for each station.

i. Miscellaneous Output. Other input parameters are printed out, including the standby crew delay time, tow-handoff distance and wait time restrictions, and the tow-hookup time. The district wide crew shift times and the times for checking queues are also printed here. The zone number and sunrise and sunset values are also printed here. The three failure criteria times, response, transit, and locate are also printed in this grouping of data. The items printed include the station and homeport refueling times.

3.3 General Capabilities and Functions

When a case is presented to the SIMULATOR, the first problem to be solved is that of selecting an ordered set of capable resources to service the case. This is accomplished by considering the Case's attributes, the resource's ability to satisfy the client's needs, the relative distances between the candidate resource's location and the client's location, and the time for the resource to get underway which includes standby crew delays.

A "capable" responder is an individual resource type which meets a hierarchy of screening tests. The tests are checks to insure that the responder can satisfy the needs of the Case for which the responder(s) is being selected to serve. The following checks are made while attempting to select a resource:

1. Check crew availability.
2. Check resource reliability.
3. Check resource weather limitations.
4. Check crew's endurance limitations.
5. Check sunrise and sunset limitations if resource is not able to operate at night.
6. Check fuel endurance.
7. Check distance offshore limitations.
8. Check if resource can handle demand(s).
9. Check service time with sunset if resource is not able to operate at night.

To establish candidacy, a resource must be available. A resource is available if it is not servicing a case or refueling. It is also available if the case to be serviced is severe, and the resource being considered is servicing a routine case.

Once the list of candidate resources has been determined, a check is made using a coefficient, which defines the probability of "failure" immediately prior to assignment. One minus the coefficient is equal to the probability that the resource is down for maintenance or repairs. In this version of the SRM, downtime distributions are not used to queue the faulty resource for a specified time interval, instead 1-coefficient, is tested against a random number to see if this resource will remain on the list of candidates to respond to the Case being processed.

Each resource, to remain a candidate for "capable" responder, must have a crew. Once the crew is assigned it remains with the resource from the time it departs the station until it returns no matter how many Cases the resource might have served while underway.

As stated in section 3.2, the analyst controls the number of hours that a crew can remain on duty aboard a particular resource. This is called crew endurance. If the crew endurance limits are reached while underway, the resource must return to base immediately and no attempt is made to find a replacement crew.

It is important to distinguish between the above method of limiting the crew's working hours as opposed to being based on the total hours that the crew is on duty during a calendar day. If a resource returns to its station due to crew endurance limitations, the crew's total operating hours are reset to zero and the same crew could go immediately on another Case. In other words, the limiter is crew endurance per underway operating hours and not crew endurance per calendar day hours.

If the Case is a rescue, the SIMULATOR will attempt to send responders that are to satisfy the need(s) of the client. During this "matching" transaction, certain resources would be disqualified due to their incapacity to perform certain kinds of service, i.e., a helicopter may not be able to do a towing job or a boat cannot provide an air escort. If the Case is a search, the needs are not known apriori so after the client is located the "matching" process is applied as above.

The service time(s) for a demand(s) is not a function of resource type, i.e., one type of responder is not considered better able to perform service on a particular client's need, than another type of responder. The responder is compelled to spend the amount of time which was assigned to the demand in the OEM. Upon Case entrance into the system, these service times are included in the necessary calculations for testing range restrictions..

Certain range restrictions must be imposed on each resource type by the analyst. It is possible that a particular craft should not be operated within a given offshore boundary or travel past a certain distance from its

home station. Crew safety, the craft's physical characteristics, regulations, rescue equipment limitations, etc., are some of the reasons for these restrictions.

Each resource type has certain physical characteristics which may prevent it from capably performing functions such as towing, escorting and/or operating in certain weather conditions. The SIMULATOR may send lesser qualified responders to a Case if other resources with greater competence do not exist at the time of the Case occurrence, i.e., an unavailable resource type may be able to cover more search miles or travel faster as a function of sea state to a severe Case. The Case attributes, sea state and visibility, may completely prevent a resource from performing on a particular Case. This is of course also true in the real SAR system.

The resource must have enough fuel to complete the Case based on its fuel consumption rate and capacity and the estimated duration of the Case. The time to transit to and from the Case coordinates added to the service times is used to estimate this duration if the Case is a nonsearch. If the Case is a search, the service times are not known apriori, so a user input variable is used in lieu of service time to estimate the minimum amount of time that the search responder will be on the Case. (See Sarsim's User's Guide, reference 10, Table 15, "User Control Input to the SRM")

Certain designated refueling type resources may be allowed to stopover along the way for fuel replenishment. (This will be discussed in detail in section 3.3.1 below). If the case is a nonsearch, lack of enough fuel to travel to and from the Case will disqualify the candidate. Searching responders will return when their supplies run low.

The resource must be able to remain on scene for a minimum amount of time predetermined by the analyst, e.g., if this amount of time were 1 hour and the responder had only enough fuel to remain in the area for 1/2 hour, the resource would not be sent on the Case. Without this constraint a responder may travel a far distance to a client only to stay for a few minutes before returning home to refuel.

Some resource types may not be able to operate at night. If this is true, the total estimated time to complete a Case must fall within the time remaining until sunset or the affected responder will be judged as incapable. If the Case is a search, the responder will be sent home before sunset. If the Case is a nonsearch, the total time to service the demand(s) must be taken into consideration. Any demand that would cause the resource to return after sunset is not assigned to the resource.

3.3.1 Refueling

The analyst can designate certain resources, (usually aircraft), as having the ability to refuel at sites other than their home stations. As well as flagging the refueling type resource, RTR, the analyst must also define each refueling site. These sites can be collocated with other stations.

Consideration of this special type of resource is done as a last resort, i.e., after every attempt has been made to assign the full complement of responders to a given Case, there is still need for more qualified resources to fill the quota.

Normal selection procedures treat the RTR in the same manner as the other resources. However, if the RTR is not selected via the special refueling algorithm it cannot stopover at refueling sites on the way, i.e., the screening tests described above do not allow a responder to be sent on a Case unless it has enough fuel. Only when the RTR is selected by the special refueling algorithm will it be allowed to stopover at refueling sites along the way.

No deviations are allowed from the refueling path due to preempts. See Section 3.3.2. If another severe Case were to occur in close proximity to the traveling RTR, the RTR would not stray from its predetermined path. This is somewhat unrealistic, especially if the original Case is routine, but will probably occur infrequently.

The refueling function of the SIMULATOR presents some very complex problems which are not fully addressed in this version of the model. For instance, if preempting were allowed many possible decisions would need to be considered based on the relative location of the RTR with respect to the refueling sites and both Case locations, the amount of fuel remaining at the "interrupt" point in time, the time to transit to both Cases, crew endurance, etc. In the real world, weather forecasts, the likelihood of finding the client(s) if searching were involved, uncertainties connected with the information received while enroute, adequacy of the various stopover facilities and paradigms due to human experience have decided influence on the strategies which are beyond the scope of this work and indeed simulation techniques in general.

The goal in this version of the model is to set up an itinerary for the RTR such that it will arrive at the Case in the earliest possible time and be able to spend the maximum amount of time on the scene. These were thought to be adequate quasi-objectives due to the likelihood of a rescue case becoming more severe as the waiting time increased and if searching is required, the RTR will not contribute to reducing the total effective miles searched until it arrives on scene. (see section 3.4.2 for Search Case Processing)

The SIMULATOR allows a maximum of two refueling stations for stopovers: the nearest, NRF, and the next nearest, NNRF, site from the Case. The methodology used in setting up the itinerary for the RTR differs as to whether the RTR is going to a Case or is returning from a Case.

If the RTR is going to a Case, the algorithm first attempts to send the RTR directly to the Case, search or perform service, and then travel to the nearest refueling site to refuel for a predetermined length of time. See figure 3.3.1 A. If the Case is a search, the RTR may return to the search area if the client is not found by the time his supply of fuel is replenished.

If it is not possible to go directly to the Case due to lack of fuel, the algorithm will attempt to send the RTR to the nearest refueling site, refuel for the specified period of time and then travel to the Case. See figure 3.3.1 B.

If the above path is infeasible, the algorithm attempts to send the RTR to the next nearest refueling site, refuel, and travel straight to the client's given location. See figure 3.3.1 C. If further refueling is needed while processing a search Case, the RTR would refuel at the nearest refueling site thus maximizing the amount of time that a RTR can remain on scene.

If none of the above paths are feasible, a final attempt is made to have the RTR refuel at both refueling sites. See figure 3.3.1 D. The SIMULATOR only allows refueling at two sites so if this path is unattainable the RTR is no longer considered a candidate. It is certainly possible that a third site may achieve feasibility, but the added complexity would not compensate for the large waiting time incurred due to the accumulated refueling times. It is expected that most of the time one site will be used and if the RTR is located a great distance from the Case it is likely that another resource would become available to service the queued Case in a more timely fashion.

When an RTR is returning home, the algorithm attempts to send the RTR via the most direct route so that it will arrive home in the earliest possible time.

The algorithm attempts to send the RTR directly home from its present location when service is completed. If this is not possible, the algorithm tries to route the RTR to the nearest refueling site before sending it home. See figure 3.3.1 E. This path may not be feasible in which case the RTR attempts to go to the next nearest refueling site. See figure 3.3.1 F.

If both the above paths are infeasible, the RTR is routed through both refueling sites. This must be a feasible path because of the way in which the RTR's are routed to Cases. See figure 3.3.1: A, B, C, D.

3.3.2 Preempting

Resources enroute, returning from, towing or escorting a client on a routine Case can be considered when selecting responders for severe Cases. If an underway resource is selected as a responder, it will be diverted to the scene of the severe incident. Clients being towed which lost their servicing resource to a severe Case will have the time and position updated and remaining service required queued until a qualified responder can be assigned to continue the service.

In selecting candidate resources on routine Cases for possible diversion to a severe Case, the only criteria for selection is that the underway responder be qualified and be the earliest calculated arrival at the scene. The specific activity that the resource was performing, (other than searching or servicing a demand on scene), does not affect selection.

If a responder is on scene servicing demands or searching it will not be preempted for a severe Case. The basic problem encountered is accounting for the amount of service time left after preemption since the service times are assigned apriori. Also, most demands, except for tows, are of a severe nature, so the impact of this limitation is probably minimal.

The SIMULATOR makes no attempt to find another resource to service the queued routine Case at the exact time that the diversion takes place. At a later time, an underway responder may travel to the queued Case when it becomes available.

The resource assignment policies can affect preempting in the sense that both underways and stations can be put into the set of candidate responders and the analyst can control the order in which they are checked. For example, if the analyst has elected to have stations checked before underways, the SIMULATOR will deduce from the speeds and relative locations of the stations the earliest arrivals ignoring the underways unless all the responders could not be assigned at the station.

3.3.3 Patrols

Selected resources, including auxiliary units, can be assigned to patrol areas with the duration of the patrol specified by the analyst. A resource so designated will depart from its home station to arrive at the patrol area center at a user determined time. For the duration of the patrol, the resource will either remain at the center point or roam randomly within a radius of the centerpoint. A resource engaged in a patrol will be considered in the determination of capable resources as a last resort, e.g., if the Case is a severe nonsearch, the patrol resource will only be considered if no other resources can be found to service demand(s) left outstanding. If the Case is a search and the SEARCH TABLE policy is in effect, the SIMULATOR will try to locate a particular type of patrol if called for in the table. For the alternative search policy, selection of a patrol resource is a last resort effort to fill the quota of missing responders.

The Sarsim User's Guide, reference 10, and section 3.2.1 shows the analyst how to initially set up the patrols. The patrols can be thought of as a separate simulation or "sub-simulation" of the SIMULATOR unless the patrol responds to a SAR Case. In this situation, the sub-simulation is in effect "interrupted" by the SIMULATOR normal activity cycles. While the patrol responder is on the SAR Case it is processed identically to the normal responders.

Many combinations of the patrol's activity cycles are possible depending upon how the analyst sets up the patrol's parameters during input. The following four modes are suggested based on experience gained during the verification phase of the project:

1. Let the patrol come into existence at its home station, transit to the specified area, stay for a time, and then return to its home station for termination.

2. Let the patrol come into existence in the area and after a given period of time has elapsed, (which could be the length of the simulation), terminate its existence.
3. Let the patrol come into existence in the area and after a given amount of time allow the patrol to terminate after transiting home.
4. Same as 1 above except occurring periodically.

Complications arise when a SAR Case's duration conflicts with the times set up for a patrol to leave the scene or return home. The SIMULATOR will not allow the patrol to go on Cases where the estimated duration of the Case overlaps the time that the patrol is scheduled to arrive home and terminate. This can cause some unrealistic situations such as; a patrol could be on its way home when a severe Case occurs nearby with no other resources available. (Note the similarity to refueling preempt limitation, section 3.3.1.) The estimated time to complete the Case in question must be greater than the time that the patrol is scheduled to terminate at its home station; otherwise, the patrol would not service the Case. In the real SAR system this would not happen if the patrol resource was qualified to handle the distress...

The patrol will return to the patrol area after servicing a SAR Case if there is time left to spend patrolling. If the patrol diverts to a SAR Case while on its way to the area, the amount of time originally scheduled for patrolling is reduced by the amount of time that the patrol spent servicing and traveling to and from the Case, e.g., the patrol will leave the patrol area at the scheduled time pre-set by the analyst, even though it might not have patrolled the full planned duration due to SAR Case interruptions.

If the patrol is in the patrol area and called away to service a SAR Case, it will leave from the predesignated centerpoint unless the analyst has set up the patrol to roam randomly in the area. In the latter case, the patrol's location is found by sampling from the circular normal distribution.

The patrol will return to its patrol area if enough time is left to patrol after completing its duties on the SAR Case. Otherwise the patrol returns home for termination.

Table 3.3.3.1 gives five simple examples to clarify the previous discussions.

In example condition A, no SAR Cases occur during the period observed. It takes the patrol 1 hour to transit to the patrol area and it stays there 5 hours patrolling.

In example condition B, a SAR Case occurs while the above patrol is on its way to its area. The Case causes the patrol to arrive 2 hours late at the centerpoint. This results in the patrol spending 3 hours instead of the desired 5 hours in the area.

Example Condition C shows that the patrol never did get to the patrol area. This was a search Case in which the patrol had to leave the search area so that it would arrive home at the necessary time of 7 hours later.

Example condition D is a situation wherein the patrol had to leave the patrol area to service a SAR Case. Note the reduction in patrolling duration.

Finally, example condition E shows the analyst allowing the patrol to come into existence in the patrol area. A SAR Case occurs and instead of spending the expected 6 hours in the area, the patrol spends 4 hours due to the time loss servicing the Case.

It is well to note that in all five examples, the patrol must always leave the area and arrive home at the prescheduled time, i.e., 6 and 7.

3.4 Case Processing

Section 3.3 described the procedures used to determine resource capability. This section outlines how the Case is processed once a set of capable resources is chosen for possible response.

Fundamentally, a Case can be broken down into three distinct types; rescue, search and search/rescue. A rescue is a Case not involving any searching. A search is a Case with only searching. A search/rescue is a Case with searching followed by servicing of demands. The response methodology for each type differs in a variety of ways.

The distinguishing feature that subdivides the rescue Cases from the search Cases is that the demands of the client are known apriori and are assigned to the resource upon departure. Demands connected with a search Case are assumed unknown until the distressed unit is located, thereby yielding the search/rescue type of Case.

The response criterion for rescue type Cases is whether or not the resource is able to handle the demand(s) of the client. Whereas, the deciding factor for search type Cases is the necessity to fill a given quota of particular resource types needed to cover the required amount of search miles.

The SIMULATOR may not be able to send all the resources needed to service a Case at the time of notification. As a result, the Case is placed in a status called "queued". A rescue Case is queued if some or all the demands of the client cannot be allocated to the capable responders. Accordingly, a search Case is queued if its full supply of responders could not be assigned at the moment of notification.

The SIMULATOR recognizes two categories of queues: completely queued and semi-queued. Completely queued implies the absence of response. This is the generally accepted notion of a queue, i.e., customers waiting in line for service. The semi-queued Case deviates from the norm in the sense

that some form of response exists, but the client requires further assistance. For example, a certain aircraft, incapable of towing, is engaged in evacuating personnel from a disabled vessel. During this period of time, another resource cannot be found to tow the craft, so the Case is semi-queued until such time that a capable resource is sent to the Case. References to queued Cases include both completely and semi-queued subsets.

In principal, a search Case can be completed without its full complement of responders, whereas, all demands must be serviced before a rescue Case is completed.

Queued Cases are checked in the following order; (1) completely queued rescue Cases, (2) semi-queued rescue Cases and (3) any queued search Cases. The preset queue check of stations for capable resources only holds for queued rescue Cases. Hence, only underway responders will query queued search Cases.

Some realism in handling queued search Cases is obtained due to possible initial unavailability of some search resources to fill the quota, especially when the Case requires a large number of responders. Consequently, as the search progresses additional responders can be added to the search. This is similar to what often happens in the SAR system. Nevertheless, the analyst has no control over these assignments. For instance, there is no provision for adding responders to search Cases as a function of how long the search lasts. The addition of search responders to queued search Cases is coincidental depending on the responders becoming available from completion of service on other Cases.

In the real world, it is indeed possible that a distressed unit may initiate response for service during the time it is queued in the SAR system, e.g., a Case first reported as routine might have a fire break out on board after initial notification which increases the severity of the Case. The client is unable to initiate response in the SIMULATOR. Therefore, queued Cases in the SIMULATOR are only checked when other events take place and the demands and severity do not change.

3.4.1 Rescue Case Processing

Prior to exercising the SIMULATOR, the analyst must rank all possible demands in order of increasing importance. As each candidate resource passes the screening tests as outlined in section 3.3, they enter a final phase of investigation called the Matching Operation, MO. The procedure followed is to try and "match" the demand(s) of the client to the resource in order of decreasing importance. This process is repeated until all demands of the Case are apportioned or the list of capable responders is empty. Unassignable demands cause the Case to be queued as outlined above in section 3.4.

Cases occurring at night will be assigned to a night capable resource to service at least one demand, if possible. Responders for the remaining demand(s), if any, will be assigned for service at first light.

A resource can be assigned multiple demands if they are not of the same type, the resource is able to perform the service, and the

service times associated with the set of demands does not exceed the maximum allowable time that the resource can remain on the Case.

As an analyst option, the initial response to an incident can be forced to consist of both surface and aviation resource types. If the SIMULATOR needs to provide one of these types in order to obtain the appropriate mixture, and as a result the missing type is supplied to the list of responders it is assigned a standby demand. Moreover, the analyst must define the service time for the standby demand. (see section 3.2) If a resource is assigned a standby demand (either a supplied or actual standby demand) it will not be allowed to service any other demands.

In order to clarify and expand on the above principles a simple example will now be given for a Case with multiple demands. Table 3.4.1 shows a hypothetical importance ranking for a sample set of demands.

Table 3.4.2. shows some example apportionments after three resources have been presented to the MO. The resources entered the MO in order from left to right. The client's ordered set of demands is: (MA,EV,EV,FF,TW,SB). In the table, assignment of a demand to a resource assumes the resource is capable of doing the demand.

The first resource presented for matching in example Condition 1, is an aircraft. The aircraft is assumed to be incapable of towing the client. Hence, it is assigned the set of demands, (MA,EV,FF), i.e., the aircraft will perform medical assistance, evacuate some personnel and fight a fire. If this were not true, some or all the demands may have been excluded from the set above.

Since a resource cannot be assigned more than one demand of the same type, the aircraft was not assigned both evacuation demands. As a result, the boat will service the second evacuation demand and tow the client. The standby demand was not included in the boat's set of demands because this type of demand must be handled by a resource with no other demands to service. Therefore, the cutter is assigned the standby demand.

Example Condition 2 changes the order in which the resources are presented to the MO. The boat is presented first, aircraft second and the cutter still in last place. The boat is given the set, (MA,EV,FF,TW), the aircraft will service the second evacuation demand and the cutter is still assigned the standby demand.

Notice the effect of changing the order of presentation of resources to the MO! The boat will likely have a higher utilization than the aircraft and the Case will probably take longer to complete because the boat will be much slower to arrive on scene. Of course, the service time connected with the standby demand could influence the total time to complete the Case. If the cutter was delayed and/or had a very long service time, the aforesaid effect might be cancelled out except for the boat's higher utilization.

If the ranking in Table 3.4.1 had been set up so that the standby demand was moved to the top of the list, i.e., becomes the most important demand, example Condition 3 would result from example Condition 2 in

Table 3.4.2. The client's set of demands would be reordered: (SB,MA,EV,EV,FF,TW). The boat would be given the standby demand neglecting all other demands in the client's list. The aircraft would take the set; (MA,EV,FF). The cutter would take the second evacuation demand and tow the client.

Severity levels can change the order in which resources are presented to the MO. Example Condition 1 may have been the result of the Case's priority being severe because the aircraft would likely arrive sooner than the other resources and therefore would have been the first resource picked for presentation to the MO. Conversely, example Condition 2 would be likely consequence of the fact that the boat was costly to operate if the Case's priority were routine.

The above examples should convince the analyst that the assignment of demands to resources depends on their order of presentation to the final matching phase of the selection process and also the initial importance ranking of the possible demand types.

Once the demand(s) are apportioned, the resource(s) are scheduled to depart their present location(s) after a possible delay. An underway resource departs immediately to the Case's reported position. If the resource was at its station, departure may be delayed by two factors: the dispatch delay and standby crew delay. These delays are additive and the resource will start its journey to the reported Case's position at the end of this time.

All service other than tows and escorts, must be performed at the reported position of the Case. The resource leaves the scene as soon as it has completed this service. Upon arrival, the resource performs service immediately, unless the only demand it is assigned to service is tow or escort. The resource assigned a tow or escort demand cannot move the distressed unit until completion of service on all other types of demands. At which time, the client is towed or escorted to the nearest station relative to the reported position of the Case. This is assumed to be the nearest facility.

The service times for multiple demands by a single responder are additive for all demands except tows and escorts which depend on the amount of time it takes to move the distressed unit to the nearest facility. This produces unrealistic behavior in the SIMULATOR. In particular, referring to Table 3.4.2, example Condition 1, assuming the medical assistance took .3 hours, the evacuation .5 hours and fighting the fire took 1.5 hours, the total amount of time that the aircraft would be serving the client would have been; $.3 + .5 + 1.5 = 2.3$ hours. These services would likely be worked on in parallel in the SAR system, thus taking less time to accomplish. This would cause the SIMULATOR to produce higher utilizations when assigned multiple demands.

Moreover, the aircraft in the above example may be preempted on its way to the Case. Afterwards, the demands might be distributed amongst underway resource(s). This produces parallel service if more than one underway responder was assigned to the Case thereby reducing total service time. The total time to service the Case would also vary

depending on the arrival times of these responders. In short, the degree of parallelism lacks apparent causal connection in the SIMULATOR.

If on scene coverage from start to finish of service occurs, it is also only coincidental. That is, once a resource is through servicing its demand(s) on scene it leaves immediately. Although, a resource assigned to tow or escort a client, would remain on scene until all servicing is completed it does not do so to provide coverage.

After responders complete service they return home using operational speed unless they are called upon to service a queued Case. Upon arrival at its home station the resource is returned to ready status and its crew returned to the appropriate ready/standby pool of crews. The fuel and endurance are reset in preparation for responding again.

3.4.1.1 Tow-handoff Processing

The analyst can designate certain resources as tow-handoff Vehicles, TV's, and they are not allowed to tow a client to the nearest facility unless the facility happens to be the TV's home station. tow-handoff resources are different from regular tow type resources that can tow to their home station as well as to the nearest facility.

The SIMULATOR allocates tow or escort demands to TV's as a last resort, i.e., no other resources can be found to handle the tow or escort demand in the MO. For example, in Table 3.4.2, example condition 4, the cutter would have taken the tow demand if the boat were the only resource designated as a TV. However, if the cutter was also a TV, the boat would have taken the tow demand and it would be handled in the manner described in this section.

The TV's simulate a type of resource which is assigned a tow but the nearest facility relative to the Case's reported position cannot accomodate the resource. Therefore, the resource must either tow the unit to its home station, which may be very far away or tow the unit closer to shore where another resource might become available to relieve the TV along the way.

The SIMULATOR approximates the above situation by allowing the analyst to define a distance offshore from the nearest station relative to the client's position thereby determining a rendezvous point for possible relief by another resource capable of towing the client the rest of the way to the nearest station. Moreover, the analyst inputs the maximum amount of time that the TV is to wait at this location before towing the client to its home station.

The Tow-handoff processing essentially treats the Case as though it were semi-queued. Selection of a relief is done in accordance with the procedures explained in section 3.4. for queued Cases. If a qualified responder is found to relieve the TV, the responder will either proceed to the rendezvous point or the reported position of the Case, depending on the location of the TV. If the TV has not yet arrived on scene at the reported position of the Case, the relief responder will head for these

coordinates. The TV will not provide coverage while the responder is enroute to the scene. If the TV has already left the scene with the client in tow, the relief responder will travel to the rendezvous point. Conversely, the TV will provide coverage in this situation. Finally, the distressed unit will be towed to the TV's home station, if a relief responder has not been found before the predetermined amount of time that the TV is forced to wait at the rendezvous location.

3.4.1.2 Abort Processing

An abort is defined as the premature interruption of a responder while enroute to service a Case.

Although somewhat confusing, the SIMULATOR treats the abort condition as if it were a demand. Service times for these psuedo demand types are zero. At the time when the abort takes place the responder is freed from further obligations to the Case. As with standby demands, the responder assigned an abort demand cannot have other demands to service.

A resource can abort a Case in three ways. In the first instance, the resource is predestined to abort at the time the abort demand is assigned in the MO. The distance that the resource is to travel from its home station is given in lieu of service time for this type of demand. The resource will depart and transit to a point on a straight line between its station and the reported Case's coordinates. No preempting is allowed for the forced abort. Moreover, it immediately returns home without checking queued Cases after reaching the above position.

The second type of abort occurs when a responder is on the way to a search and the search is terminated. The responder does not continue to the search area. It will abort at its present location and be available to service queued Cases or return to its station.

The third type of abort occurs when a TV on the way to a Case is to be relieved of the tow at the Case's position. A TV on its way to the reported position of a Case with another responder scheduled to relieve the tow continues to the Case's coordinates and if the TV is not assigned other demands it immediately leaves the scene. That is, the TV abort takes place on scene whereas the other two types take place before arrival on the scene.

3.4.2 Search Case Processing

The search responders are subjected to the same screening tests as rescue Case responders. Similarly, selected responders proceed to the search origin in the same manner as described for rescue responders.

The search responders start searching when they reach the origin of the search area. The responder does not roam about as in the real world. Instead, it is effectively positioned at the given origin of the search. Consequently, the passage of simulated time accounts for the time each spends searching.

The OEM determines the total time spent searching for each resource that was assigned to the historical search Case and from that calculates the total miles searched, TSEM. (See section 2.0 for the details). The SIMULATOR's search responders must cover this effective distance in order to terminate the search.

The same quantity and types of resources that were utilized historically will not likely be the same as the SIMULATOR's search responders. Their relative positions from the search origin before departure will also differ from history thereby producing different arrival times on scene.

To obtain the contribution of effective miles searched for each resource assigned to a search in the SIMULATOR we use the following formula:

$$\text{Miles searched} = \text{linear miles traveled} \times \text{Coverage Factor}$$

where linear miles traveled is calculated by multiplying the operational speed of the resource by the time it will remain on scene. The Coverage Factor is a weight assigned to each resource that can vary the effectiveness of the individual search resource, i.e., if this coefficient is less than one the resource would take longer to cover the area than if it were greater than one.

The table below shows an example of a particular situation at some time during the search:

<u>Resource</u>	<u>Hours on Scene</u>	<u>Search Speed</u>	<u>Factor</u>	<u>Total Miles</u>
Helicopter	2	110	4	880
WPB	3	10	3	90
44 MLB	2	10	3	60
				<hr/> 1030 miles

Table 3.4.3 Accounting for Search Miles

The item, Total Miles is the maximum amount of effective miles that the resources could cover, given that they all started at the same time. The amount that must be covered, TSEM, could be less than or greater than this total. If the amount were greater the search could not be completed by these resources. In the above example, a time can be scheduled for completion of the search if TSEM were less than 1030 miles. Furthermore, if the resources all arrived on scene at the same time with none leaving the scene before the search is terminated, finding the time to end the search is trivial, e.g., if TSEM was 500 miles the search would be over in about 1/2 hour, i.e., $500 / (880 + 90 + 60) = 1/2$.

However, there is no reason to believe that the above simple situation will be true in general. Table 3.4.4 shows a typical situation in which the times of arrival vary and the responders leave the search area before the search is terminated. The analyst should study this example carefully to get a feel for the complications that arise in calculating the time that the search must end before reading further.

Basically, the problem that must be solved is: given a set of search resources, not arriving on scene at the same time, find the time, TE, at which the sum of the resource's effective miles is equal to the historical effective miles searched, TSEM. The resources can operate in parallel and may leave and return to the scene before the search terminates. The time, TE, fluctuates as resources arrive and leave the scene.

The following algorithm solves this general problem. The algorithm is applied each time a resource arrives on the scene. (Note: the sign, "=", denotes "is replaced by" and "*" is the multiplication operator).

Algorithm for determining the time to end the search, TE:

- A1: (Initialize and determine the maximum amount of time that the resource can remain in the area, LOT)
 $TUS = SST - HFS$; if resource must return before sunset
 $= \text{infinity}$; otherwise
 where SST is hour of sunset and HFS is the present hour of the day and TUS is the time remaining until sunset.
 $TBF = AMT/CX$
 where AMT is the maximum amount of fuel that the resource has in its tank, CX is resource's rate of fuel consumption and TBF is time that the resource can remain in area from fuel considerations.
 then
 $LOT = \text{MIN}(TBF, TUS) - TR$
 where TR is the transit time from the responder's home station to the centroid of the search area.
- A2: (Find the maximum effective mileage resource can cover, EM)
 $EM = X * Y * LOT$
 where X is Coverage Factor and Y is search speed.
- A3: (Store maximum amount of search mileages attainable by all the resources that have arrived on scene up to the present time, if any, in THRES)
 $THRES = THRES + EM$
- A4: (Can a time, TE, be found for the end of the search?)
 If THRES is less than TSEM, terminate the algorithm; otherwise go on to the next step
- A5: (Is this the first resource to arrive in the area?)
 If true, terminate the algorithm; otherwise go on to the next step
- A6: (This is not the first resource to arrive in the area! Has TE been determined yet?)
 If true, go to step A18; otherwise continue on to the next step
- A7: (Determine the amount of mileage that has been covered by all the resources, AM, and reduce TSEM by this amount)
 $RTSEM = TSEM - AM$

- A8: Store all the resources speeds in the set VELs.
- A9: (Find the maximum amount of time each resource will be on scene, MAXOS)
Store MAXOS in the set TIMAX.
- A10: Search the set, TIMAX, for the first resource that will leave the scene.
- A11: Let SMLL be equal to the value of the element thus found in the previous step, A10.
- A12: Add all the speeds in the set VELs to the variable SVEL
- A13: (Determine the mileages of all the resources up to the present time)
 $SRSOFAR = SVEL * SMLL$
- A14: (Can TE be determined yet?)
If SRSOFAR is greater than or equal to RTSEM
 $TE = RTSEM / SVEL$
Terminate the algorithm; otherwise continue on to the next step
- A15: $RTSEM = RTSEM - SRSOFAR$
 $TE = TE + SMLL$
- A16: Set the speed of the resource just considered to zero in the set VELs.
- A17: (Process the next earliest departure time resource)
Subtract SMLL from each element in set TIMAX
Go back to step A10
- A18: (TE has been calculated previously, so this resource will reduce the time to end the search)
Determine the amount of mileage left to cover, RTSEM.
- A19: Sum up all the speeds and store them in variable EFS.
- A20: (Calculate the percent of TSEM remaining)
 $BETA = TRO / TF$
where TRO is the time interval between the present time, TE, and TF is the passage of time since TE was last calculated
- A21: (Calculate the new reduced TE)
 $TE = BETA * RTSEM / EFS$
- A22: If any search responders will leave the scene before TE hours, add the amount of this mileage that will not be covered to RTSEM and recalculate
 $TE = RTSEM / EFS$

While the responder is in the search area it may leave the area if its fuel supply is low. Moreover, it will leave the area such that it will return home before sunset if it cannot operate at night. In the former instance, the responder will go to its home station if it is not a refueling type resource or to the closest refueling station if the analyst has

designated the responder as a refueling type responder. After its fuel is replenished, it returns to the search area if the search has not terminated. In the latter situation, the responder will return to its home station and remain overnight. The responder will return to the search origin the following day if the search has not ended by then. A refueling type resource that is restricted to operate only during the day could end up remaining overnight at a refueling site.

If the distressed unit has been located and requires servicing, the search responders assigned to the search are checked for capability in the same manner as prescribed in section 3.3 in the following order: (1) responders positioned at the origin of the search, (2) responders scheduled to arrive at the origin of the search and (3) responders having left the origin of the search traveling to a refueling station or their home station.

If all or some of the demands have not been fulfilled by the search responders, resource types at the stations are checked in the same manner as described in section 3.4.1.

Finally, when the search has terminated, all responders assigned to the search and not servicing demands return to their home stations via the most direct route. Responders completing service are processed in the same manner as described in section 3.4.1.

3.5 Output of the SIMULATOR Reports

The printed output from the SIMULATOR is divided into four reports as follows:

a. Summary Statistics by Facility.

This report provides a concise table showing the individual station as well as the group performance for a simulation run. The performance statistics include the number of responses, assists, and sorties rendered by each station. A response is counted each time a station provides at least one resource to a case, an assist is counted each time a station provides the resource which is first on scene but is not the closest station, and a sortie is counted each time a resource is sent to the case. The total number of responses, assists, and sorties for the stations within a group is also shown. Following these three statistics, the number of queued cases from each station (i.e., the closest station to the case is credited) is given. Again, the group total is provided. The next three statistics provided are the average wait time, the average transit time, and the average distance to the scene. The average wait time for a facility is the average of all the times that each of the cases waited from the time of occurrence to the arrival of a resource (it includes any dispatch delay, crew delay, transit and search time) on scene. The average transit time is the average of the elapsed times for each case between dispatch of the first resource from the facility and its arrival on scene or in the search area. It should be noted that if a second resource is dispatched to the case and arrives sooner than the first dispatched, then the time would be counted from this second resource's dispatched time, i.e., transit time is based on the first arriving resource's time. Distances to the scene are calculated as straightline distances from the facility. The group averages for these statistics represent the average of time (or distances) for all of the stations, i.e., not the average of the station average. The number of demands performed by each station and the group total is also provided. Additionally, the resource operating costs for each station as well as the costs for the group are presented. Utilization statistics follow and they include both resource utilization and crew utilization for weekdays and weekends. In both cases utilization refers to the percentage of total available hours that are spent underway. Then, for each station, as well as the groups, the number of standby crews that were both called and sent out on sorties is shown. The standby crew data is followed by the number of cases that were considered severe. The criteria failures, transit, locate, and response, which are discussed in the section below under the exercise summary report are also presented by station and group. They only pertain to severe cases. Finally, the average excess response time for each station, as well as the excess found over all cases for all stations within a group, is given, where the excess response time refers to the amount of time it took the first resource to get alongside from notification over and above the user provided response failure criteria time. It also only pertains to severe cases.

b. Resource Sortie Profile.

This output report provides a summary of resource statistics by type (e.g. 17UTL, 95PAT, 92WPB, HH3F, C130) and by category (i.e., small boats, patrol boats, cutters, rotary, and fixed wing aircraft, and others). The three statistics which are presented are total operating hours, utilization (operating hours divided by total available hours including the down time), and total operating costs. These statistics are presented both by type and category in two tables. The types are, however, listed in their categorical order. That is, all small boat types are listed, followed by the patrol boat types, etc.. This report provides a list of the demand types and their respective frequency of occurrence. Additionally, the percentage of total occurrence is given for each type.

c. Exercise Summary Report.

This report is intended to present some of the most significant summary statistical data about the run. It also provides information to help the user keep track of his exercises. That is, the report includes the district numbers, date of execution, time period and dates of the simulation and comments about the run which are a user input. A figure of merit is also reported where the calculation for this is explained in more detail in Reference 10.

The summary statistics are divided into four categories which are the case statistics, some miscellaneous statistics, the resource statistics, and the criteria failures for severe cases only. The case statistics are presented for each of the two time slots, weekends and weekdays. The total of the two time periods is also presented. The case statistics include the number of cases that occurred and the number of cases completed, as well as the percentage of the cases completed. It should be noted that the cases are counted according to the time slot in which the case occurred.

The miscellaneous statistics include the average wait time and the average time a case is in queue. Wait time is the elapsed time between notification of the distressed and arrival of the first responding resource. The average queue time represents the average of those cases that were in queue only. The average distance offshore, total number of responses, and total number of sorties are also presented. The number of responses represents the number of times a facility responded to cases, i.e., regardless of the number of resources provided by a facility for a particular case, only one response is counted. Total enroute time and total search time are also presented. Total enroute time is the total time used to transit to cases and total search time is the total time spent in the designated search area.

The summary resource statistics include the total operating hours, total utilization, and the total operating costs. Total operating hours is the sum of all individual resources operating hours. The total utilization is equal to the total operating hours divided by the total hours that the resources are available. The hours of availability do not exclude those times during which a resource is found to be down via the user provided reliability probability. The total operating costs is based on the hours of operation times the hourly costs for operating the various resource types.

The last set of statistics presented in this table includes the number of failure occurrences by type for severe cases only. The types include transit, locate, and response failures. A transit failure is defined as a case where the elapsed time between dispatch and arrival of the first responder on scene and actual location of the distressed unit exceeds the user specified time. A response failure is defined as a case where the elapsed time from initial notification until a resource is alongside exceeds the user specified time for such a failure.

d. Facilities Resource Summary.

This report provides a summary of the resource usage at each station, which is denoted with its identifier. Each resource is listed along with the total number of sorties it performed and its total operating hours and utilization. The number of the various demand types performed by each resource is also presented in this summary report.

Condition	Case	Priority	Resource	Time of Notif	Time Departed	Time Arrived on scene	Time Left the scene	Time Arrived at Dock or refuel- ing site	Time Arrived Home	Waiting Time (hours)
A	1	0	#1	0800	0830	0915	0930	1000	1030	1.25
B	2	0	#1	0800	0900	0945	1000	1030	1100	1.76
C	1	0	#1	0800	0830	---	---	---	---	---
	2	1	#1	0845	0850	0920	1045	---	1115	.58
	1	0	#2	---	0902	0930	0945	1015	1145	1.5
D	3	--	#1	1300	1330	1400	1700	---	1730	.?
E	3	--	#2	1305	1345	1355	1500	1520	---	---
	--	--	#0	---	---	1615	1830	---	1901	.?

Table 3.1.1 SIMULATOR Behavior

TABLE 3.2.1
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>																																												
1	TRACE FLAG	Flag which activates trace (programmer's debugging aid) 1 Indicates traces will be activated																																												
2	EVENT TRACE	Flags indicating the desire for traces of the actual case data for particular events; the following is a list of the element numbers and their corresponding events <table><tr><td>1</td><td>NOSRCH</td><td>12</td><td>TERMPA</td></tr><tr><td>2</td><td>ABORT</td><td>13</td><td>ENIGMA</td></tr><tr><td>3</td><td>ARVSNE</td><td>14</td><td>FILLUP</td></tr><tr><td>4</td><td>HANDTOW</td><td>15</td><td>ARVSRH</td></tr><tr><td>5</td><td>TOWARV</td><td>16</td><td>LVSRCH</td></tr><tr><td>6</td><td>LVSCEN</td><td>17</td><td>ARVHOM</td></tr><tr><td>7</td><td>GETHOM</td><td>18</td><td>STATE</td></tr><tr><td>8</td><td>GOHOM</td><td>19</td><td>ENDSRH</td></tr><tr><td>9</td><td>INPATR</td><td>20</td><td>set to 1 always</td></tr><tr><td>10</td><td>ACTPAT</td><td>21</td><td>FINIS</td></tr><tr><td>11</td><td>RTNPAT</td><td>22</td><td>set to 1 always</td></tr></table>	1	NOSRCH	12	TERMPA	2	ABORT	13	ENIGMA	3	ARVSNE	14	FILLUP	4	HANDTOW	15	ARVSRH	5	TOWARV	16	LVSRCH	6	LVSCEN	17	ARVHOM	7	GETHOM	18	STATE	8	GOHOM	19	ENDSRH	9	INPATR	20	set to 1 always	10	ACTPAT	21	FINIS	11	RTNPAT	22	set to 1 always
1	NOSRCH	12	TERMPA																																											
2	ABORT	13	ENIGMA																																											
3	ARVSNE	14	FILLUP																																											
4	HANDTOW	15	ARVSRH																																											
5	TOWARV	16	LVSRCH																																											
6	LVSCEN	17	ARVHOM																																											
7	GETHOM	18	STATE																																											
8	GOHOM	19	ENDSRH																																											
9	INPATR	20	set to 1 always																																											
10	ACTPAT	21	FINIS																																											
11	RTNPAT	22	set to 1 always																																											
3	SEARCH TRACE	Flag indicating the desire for search traces 1 Indicates traces will be activated																																												
4	NONSEARCH TRACE	Flag indicating the desire for nonsearch traces 1 Indicates traces will be activated																																												
5	UNDERWAY TRACE	Flag indicating the desire for underway traces 1 Indicates traces will be activated																																												
6	SIMULATION DAYS	Period of time to be simulated in days																																												
7	START MONTH	Month (1-12) of the simulation start date																																												
8	START DAY	Day (1-31) of the simulation start date (must be on a Monday)																																												
9	START YEAR	Year (last two digits) of the simulation start date																																												

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
10	JULIAN DATE	Julian date used for sunrise/sunset calculations (corresponds to start date)
11	REPORT FLAG	Flag indicating the desire for printed output reports 1 Indicates the desire for the reports 0 Indicates the reports are to be suppressed
12	POSTPROCESSOR FLAG	Flag indicating the desire to collect and save the detailed case data for postprocessor 0 Indicates the recording of the data should be suppressed 7777 Indicates the desire for the data
13	ECONOMIC POLICY	Economic policy code for resource selection 1 Selection based on hourly ranked cost, i.e., seek the minimum ranking 2 Selection based on hourly ranked cost * transit time, i.e., seek the minimum transit cost 3 Selection based on speed of resource, i.e., seek the resource that can arrive soonest 4 Same as 1 except that all ranks are equal. Selection is somewhat random from a FIFO set.
14	STATION POLICY (ROUTINE)	Policy code determining the facilities or groups to be checked in resource selection for a routine case 1 Select from nearest station only 2 Select from nearest group only 3 Select from nearest station and adjacent station

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
		4 Select from nearest station within entire district, i.e., attempt to find a resource at nearest station and if none found, check the next nearest station, etc.
15	INTERRUPT POLICY	<p>Priority interrupt policy code for resource selection of underway resources for severe cases</p> <p>1 No interruptions permitted</p> <p>2 Select from underways, then, if necessary, from resource types at facilities</p> <p>3 Select from resource types at facilities then, if necessary, from underways</p> <p>4 Select from mixed set of resource types at facilities and underways</p>
16	STATION POLICY (SEVERE)	<p>Resource selection policy code for severe cases</p> <p>1 Select from nearest group only</p> <p>2 Select from all available resources i.e., similar to specifying a 4 in element 14, ADJACENT</p>
17	CREW FLAG	<p>Flag indicating whether or not individual station crew shift times are specified</p> <p>0 Indicates station by station crew shifts not being implemented</p> <p>1 Indicates station by station crew shifts are being implemented and that the times are specified in the crew data</p>
18	SEARCH FLAG	<p>Flag indicating the search resource selection method</p> <p>0 Indicates that the preferred and alternative resources for searches are specified as a user input (elements 77-83)</p>

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
		1 Indicates that the simulator will select the number of search resources based upon the historical number of resources
19	NONSEARCH MIX FLAG	Flag indicating whether or not the accompanying resource policy* is to be in effect for nonsearch cases 0 Accompaniment not required 1 Accompaniment required
20	SEARCH MIX FLAG	Flag indicating whether or not the accompanying resource policy* is to be in effect for search cases 0 Accompaniment not required 1 Accompaniment required * Accompanying resource policy requires a mix of air and surface resources on cases
21	SERVICE TIME FLAG	Random service times flag NO Constant service times for all demands YES Random service times will be used for demand servicing. Means are given in element 126
22	DISPATCH TIME FLAG	Random dispatch delay flag NO Constant dispatch delay times YES Random dispatch delay times. Given dispatch delays are used as means (elements 121-122).
23	STANDBY TIME FLAG	Random standby times NO Constant standby times. Element 29 is a constant standby delay. YES Random standby times. Element 29 is a mean standby delay.

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
24	SEARCH OFFSHORE CRITERIA	Distance offshore which defines search resource group classification (n. mi.) * Element 24 need only be specified if element 18 is a 0.
25	TOW HANDOFF OFFSHORE DISTANCE	Minimum distance from shore required to tow (n. mi.), i.e., distance where a tow-handoff would take place
26	TOW HANDOFF WAIT TIME	Time resource will wait for a handoff (hours)
27	TOW HOOK UP TIME	Time it takes to hook up for a tow (hours)
28	STANDBY SERVICE TIME	Service time for accompanying resources performing only a standby demand * Element 28 specified only if element 19 or 20 is set to 1.
29	STANDBY CREW HOURS	Constant or mean time to ready a standby crew (hours). See element 23.
30	AIRCRAFT REFUELING TIME	Time to refuel an aircraft at any refueling station (hours)
31	RESOURCE REFUELING TIME	Down time to refuel a craft at its home station (hours)
32	CREW SHIFT TIME	Time to shift a standby crew to ready status (time of day based on twenty-four clock), e.g., 2230 = 22.5
33	CREW SHIFT TIME	Time to shift the ready crew back to standby status (hours) * Elements 32 and 33 are negative if the district wide crew shift is not being implemented and apply only to district wide crew shifts.
34	RESPONSE CRITERIA	Response failure criteria time (hours)
35	TRANSIT CRITERIA	Transit failure criteria time (hours)
36	LOCATE CRITERIA	Locate failure criteria time (hours)

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
37	EVENT TIME	Time for activating an event, which accumulates statistics, but no longer used, so best set to 0.0
38	QUEUE CHECK FLAG	Flag indicating whether or not calling READI to check the queued cases is desired 1 Indicates wants to check queues and that the data follows = 1 Indicates that queues should not be checked
39	NUMBER OF TIMES TO CHECK QUEUES	Number of times during each day that queues will be checked (this number of times follows)
40	TIMES TO CHECK QUEUES	Times of the day to check queues (24-hour clock)
41	TIME TO START TRACES	Time to start snapshot dumps (days)
42	TIME TO STOP TRACES	Time to stop snapshot dumps (days)
43	TIME ZONE	Time zone of the district from Greenwich, e.g., Eastern seaboard is district 5 used for sunrise/sunset calculations
44	ECHO FLAG	Flag indicating option for printing the input data 9999 Input data printed = 9999 Printout of input data suppressed
45	PATROL FLAG	Flag indicating patrol options 0 No patrols 1 Patrols are specified (see elements 107-120)
46	SUNRISE/SUNSET FLAG	Flag specifying constant or calculated sunrise and sunset 1 Constant sunrise and sunset = 1 Calculated sunrise and sunset

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
47	SUNRISE TIME	Time of day for sunrise (hours); specified only if constant time desired; 24-hour clock
48	SUNSET TIME	Time of day for sunset (hours); specified only if constant time desired; 24 hour clock
49	NUMBER OF CATEGORIES	Number of resource categories. Set to 6
50	NUMBER OF TYPES	Number of resource types following
51	NAME	Name of resource type
52	COST	Operating cost of resource per hour (dollars)
53	TOW LIMIT	Maximum tonnage that can be towed at given speeds
54	AIR/SURFACE FLAG	Flag indicating traveling medium 0 surface 1 air
55	SEA STATE	Maximum allowable sea state for operating (feet)
56	VISIBILITY	Minimum visibility required for operations (n.mi.)
57	ON SCENE TIME	Minimum allowable time on scene (hours)
58	DAY/NIGHT FLAG	Day and night operations flag 0 Day and night operations, no refueling 1 Day operations only, no refueling 100 Day operations only with refueling 101 Day and night operations with refueling
59	FUEL RATE	Fuel consumption (gallons/hour)
60	FUEL CAPACITY	Fuel capacity (gallons)
61	CREW	Maximum crew endurance (hours)

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
62	MAXIMUM DISTANCE	Maximum allowable distance from homeport or facility (n. mi.)
63	OFFSHORE DISTANCE	Maximum allowable distance offshore for operations (n. mi.)
64	NUMBER OF DEMANDS	Number of assistance demands that cannot be performed
65	CATEGORY FLAG	Category <ul style="list-style-type: none"> 1 Boat 2 Patrol 3 Cutter 4 Rotary wing aircraft 5 Fixed wing aircraft 6 User assigned value
66	DEMANDS	Name of assistance demands that cannot be performed (from user selected demand names)
67	NUMBER	Number of resource types with speeds specified. This number should be the same as element 50.
68	NAMES	Name of the resource type
69	OPERATING SPEED	Normal operating speed (knots)
70	ENROUTE SPEED	Maximum speed with a sea state greater than 5 feet (knots)
71	ENROUTE SPEED	Maximum speed with a sea state less than or equal to 5 feet (knots)
72	TOW SPEED	Towing speed with a sea state greater than 5 feet (knots)
73	TOW SPEED	Towing speed with a sea state less than or equal to 5 feet (knots)

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
74	NUMBER OF RESOURCES	Number of resource types with search coefficients specified. This number should be the same as element 50.
75	NAMES	Name of the resource type
76	SEARCH COEFFICIENT	Search speed coefficient; factor which allows for improved search effectiveness by allowing for earlier completion of the search, i.e., if set equal to 2.0, resource would complete search twice as fast
77*	NUMBER OF SEARCH RESOURCES	Number of resource types with search environment codes specified; these are the preferred resources * Elements 77-83 entered only if element 18 = 0
78	NAMES	Name of resource type
79	SEARCH CODE	Search environment code 1 Routine, less than SHORE n.mi. offshore 2 Severe, less than SHORE n.mi offshore 3 Routine, greater than or equal to SHORE n.mi. offshore 4 Severe, greater than or equal to SHORE n.mi offshore SHORE is the user selected variable, element 24
80	NUMBER OF SEARCH RESOURCES	Number of resource types considered for search assignment as alternates to those specified in element 77
81	RANK	Rank of each resource type within a resource category for substitute resource assignment when the preferred is unavailable
82	NAMES	Name of resource type

TABLE 3.2.1 (continued)
User Control Input to The Simulator

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
83	SEARCH CODE	Search environment code 1 Routine, less than SHORE n.mi. offshore 2 Severe, less than SHORE n.mi offshore 3 Routine, greater than or equal to SHORE n.mi. offshore 4 Severe, greater than or equal to SHORE n.mi. offshore SHORE is the user selected variable, element 24
84	NUMBER OF GROUPS	Number of group of stations/facilities
85	GROUP NUMBERS	Unique number identifier for each group. Note, if 0, a refueling station is implied. The refueling group must follow all other groups. 7777 is used to specify a patrolling group.
86	GROUP LATITUDE DEGREES	Latitude of the centroid of the group (degrees)
87	GROUP LATITUDE MINUTES	Latitude of the centroid of the group (minutes)
88	GROUP LONGITUDE DEGREES	Longitude of the centroid of the group (degrees)
89	GROUP LONGITUDE MINUTES	Longitude of the centroid of the group (minutes)
90	NUMBER OF STATIONS	Number of stations in the group
91	STATION NAME	Station designator (e.g., STAA)
92	TYPE STATION FLAG	Type of station 0 Non-air station 1 Air station

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
93	STATION LATITUDE DEGREES	Latitude of the station (degrees)
94	STATION LATITUDE MINUTES	Latitude of the station (minutes)
95	STATION LONGITUDE DEGREES	Longitude of the station (degrees)
96	STATION LONGITUDE MINUTES	Longitude of the station (minutes)
97*	NUMBER OF TYPES	Number of resource types at a station * Elements 97-106 are not entered for refueling group, group 0.
98	NUMBER OF A TYPE	Number of a particular type of resource at a station, where the type is specified in element 99.
99	TYPE	Name of the resource type
100	AVAILABILITY PARAMETER	Availability parameter indicating the probability that the resource type is capable of getting underway when needed (0. to 1.)
101	DISPATCH DELAY FLAG	Dispatch delay array index pointing to dispatch delay in list entered as element 121.
102	RELATIVE COST	Relative ranking for resources at the station
103	NUMBER CREWS	Number of crews at each station
104	CREW STATUS	Readiness code for the crew Ready crew Standby crew 1 Weekdays only 100 Weekdays only 2 Weekends only 200 Weekends only 3 Weekdays and 300 Weekdays and weekends weekends

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

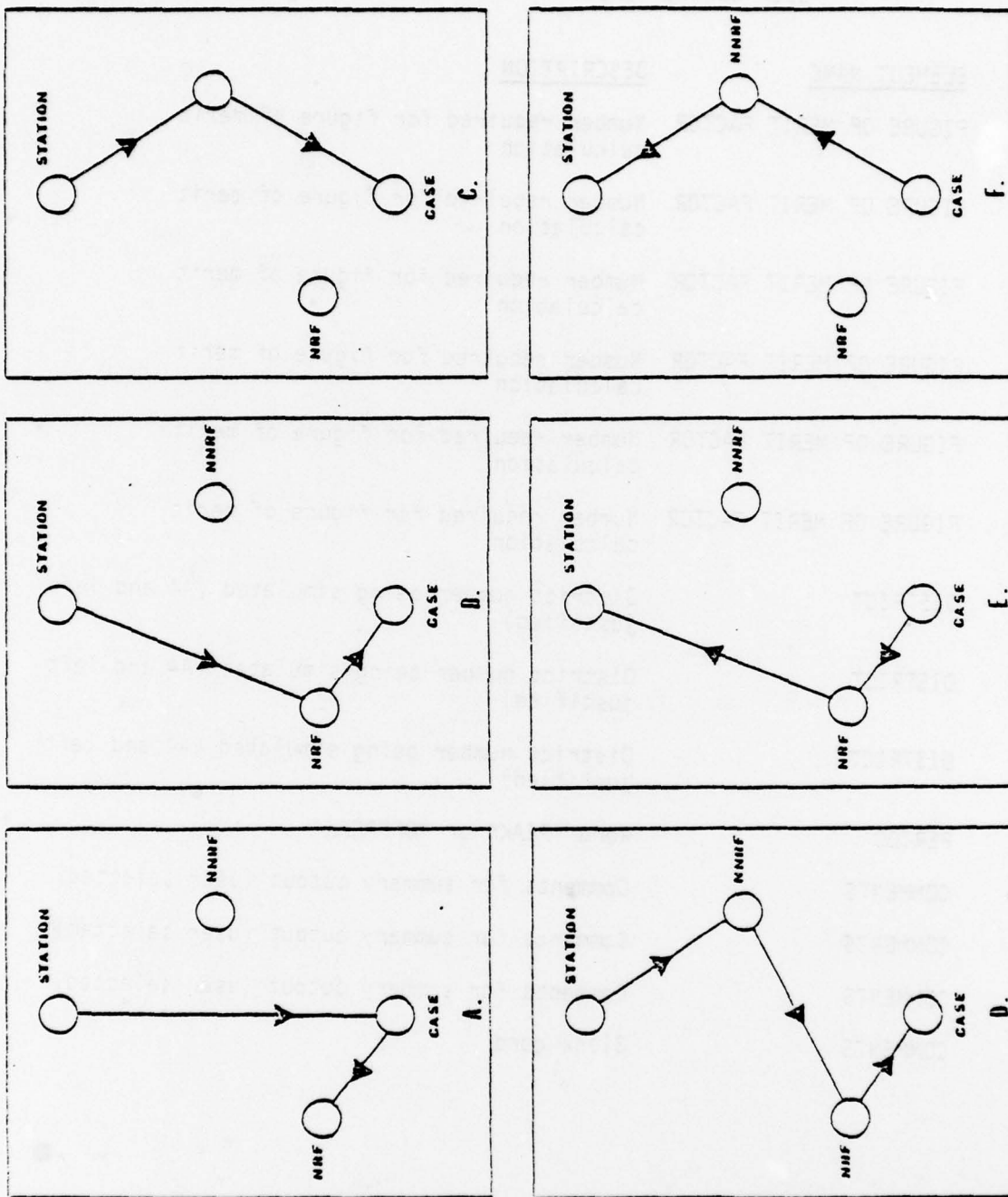
<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
105	CREW SHIFT TIME	Time to begin a crew shift (hours) (24 hour clock)
106	CREW SHIFT TIME	Time to end a crew shift (hours)(24 hour clock) *Elements 105 and 106 are specified only if element 17 is set to a 1 and only for ready crews. Ready crews exist between these times.
107	NUMBER OF PATROLS	Number of patrols desired. Enter elements 108-120 for each patrol.
108	PATROL NAME	Name of patrol. Must correspond to a name given in element 51.
109	PATROL HOME STATION	Name of the patrol's home facility or port
110	CONTROL EVENT	Name of control event INPATR patrol assignment RTNPAT schedules a return home for a patrol
111	PATROL LATITUDE DEGREES	Latitude of the center of the patrol area (degrees)
112	PATROL LATITUDE MINUTES	Latitude of the center of the patrol area (minutes)
113	PATROL LONGITUDE DEGREES	Longitude of the center of the patrol area (degrees)
114	PATROL LONGITUDE MINUTES	Longitude of the center of the patrol area (minutes)
115	PATROL TIME	Amount of time patrol will remain in the area (hours)
116	PATROL DIAMETER	Diameter of the patrol area if the patrolling resource type is not restricted to the center point.

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
117	PATROL FLAG	Flag describing patrol activity 1 Periodic on scene times 2 Patrol is fixed at his homeport 3 Random on scene times
118	PATROL FLAG	Flag describing the mechanism for starting a patrol 1 All external 2 Periodic interval start times 3 Random interval start times
119	PATROL SCHEDULE	Time (days) to schedule the patrols if they are not external, i.e., element 118 is not set to a 1.
120	PATROL START TIME	Time (hours) event is to initially occur
121	NUMBER OF DISPATCH DELAYS	Number of dispatch delay times specified
122	DELAYS	Dispatch delay times (hours) See elements 22 and 101.
123	NUMBER OF DEMANDS	Number of demand codes
124	DEMANDS	Name of each demand code
125	DEMAND RANK	Ordinal code accompanying the demand name, indicating the service ranking. Enter in same order as ranked. Do not enter SURCH demand.
126	MEAN SERVICE TIMES	Demand service time mean if random service times are specified in element 21
127	FIGURE OF MERIT FACTOR	Number required for figure of merit calculation
128	FIGURE OF MERIT FACTOR	Number required for figure of merit calculation

TABLE 3.2.1 (continued)
User Control Input to The SIMULATOR

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
129	FIGURE OF MERIT FACTOR	Number required for figure of merit calculation
130	FIGURE OF MERIT FACTOR	Number required for figure of merit calculation
131	FIGURE OF MERIT FACTOR	Number required for figure of merit calculation
132	FIGURE OF MERIT FACTOR	Number required for figure of merit calculation
133	FIGURE OF MERIT FACTOR	Number required for figure of merit calculation
134	FIGURE OF MERIT FACTOR	Number required for figure of merit calculation
135	DISTRICT	District number being simulated (A4 and left justified)
136	DISTRICT	District number being simulated (A4 and left justified)
137	DISTRICT	District number being simulated (A4 and left justified)
138	PERIOD	Word "PEAK" or "OFFPEAK"
139	COMMENTS	Comments for summary output (user selected)
140	COMMENTS	Comments for summary output (user selected)
141	COMMENTS	Comments for summary output (user selected)
142	COMMENTS	Blank card



Refueling Paths
FIGURE 3.3.1.1

Condition	Start	Arrive at SAR Case	Arrive in Patrol Area	Leave Patrol Area	Arrive at SAR Case	Arrive in Patrol Area	Leave Patrol Area	Arrive at Home station & Terminate
A	0	--	1.0	---	---	---	6.0	7.0
B	0	0.5	3.0	---	---	---	6.0	7.0
C	0	0.5	---	---	---	---	---	7.0
D	0	---	1.0	2.0	2.5	4.0	6.0	7.0
E	--	---	0	3.0	3.5	5.0	6.0	7.0

- A: Patrol is to stay in area 5 hours - no SAR Cases occur
- B: SAR Case occurs while patrol on its way to area - patrol only stays in area 3 hours instead of 5 hours.
- C: Search Case occurs and patrol never gets back to the area; it is sent from the search to arrive back in 7 hours.
- D: SAR Case occurs while patrol in the area. Patrol spends 3 hours in the area
- E: Patrol comes into existence at the centerpoint and should have spent 6 hours in area but SAR Case occurs so patrol only spends 4 hours in the area.

Table 3.3.3.1 Five Simple Patrol Examples

<u>Rank</u>	<u>Demand Type</u>	<u>Mnemonic</u>
1	Medical Assistance	MA
2	Evacuation	EV
3	Fight Fire	FF
4	Tow	TW
5	Escort	ES
6	Standby	SB
7	Deliver Equipment	DE

Table 3.4.1 Set of Demands Ranked by Importance

<u>Aircraft</u>	<u>Boat</u>	<u>Cutter</u>	<u>Boat</u>	<u>Aircraft</u>	<u>Cutter</u>
MA	EV	SB	MA	EV	SB
EV	TW		EV		
FF			FF		
			TW		
Condition 1			Condition 2		
<u>Boat</u>	<u>Aircraft</u>	<u>Cutter</u>	<u>Aircraft</u>	<u>Boat</u>	<u>Cutter</u>
SB	MA	EV	MA	EV	SB
	EV	TW	EV		
	FF		FF		
Condition 3			Condition 4		

(Resources matched from left to right)

Table 3.4.2 Demand Matching and Assignments

Type of Resource	Present Time	Effective Speed of Resource	Amount of time it can remain	Effective Miles searched so far	Present TSEM	Search will be over in hours	Notes:
	0.0				1000	?	1
HH #1	1.0	150	2.0	0	1000	?	2
HH #2	2.0	100	2.0	150	850	?	3
BOAT	3.0	20	200.0	400	600	25	4
HH #1	4.0	150	2.0	480	520	11	5
HH #2	5.0	100	2.0	650	350	2	6

SEARCH WILL END IN 7 HOURS

NOTES

1. A search case has arrived into the system at relative time zero hours. The total effective miles that must be searched is 1000 miles.
2. One hour later a helicopter, HH #1, arrives on scene and begins to search with a speed of 150 knots. Due to fuel constraints it must leave the scene in 2 hours. Therefore, it can only cover $150 \times 2 = 300$ effective miles which is less than the required amount of 1000 effective miles. So it is not known when the search will end.
3. Another aircraft, HH #2, arrives on scene 1 hour after the first, HH #1, or 2 hours since the search case came into the system. The first helicopter has covered 150 miles up to now, so there is 850 miles left to search. However, both these aircraft together cannot complete the 850 miles given the amount of time they can remain on the scene. The analyst can verify this: $850 \text{ divided by } (200 + 150)$ is greater than 2 hours. This is when the last aircraft will leave the scene.
4. Now a boat arrives that can stay 200 hours in the area. We cannot use the simple relationship of dividing TSEM by the sum of the effective speeds of all the resources to find the time that the search ends due to the fact that all the resources will not be on the scene throughout this period of time, e.g., HH #1 has left and HH #2 will leave in 1 hour so it will not contribute effective miles past this point in time. A possible procedure, in this simple example, is to move up to the point in time when the HH #2 is going to leave and determine the miles left to search which is 480. We then divide this amount by 20, the speed of the boat, to get 24. The end of the search is $24 + 1 = 25$ hours from the present time.

5. Here we have a similar situation. We move up 2 hours which gives 340 miles covered by boat and aircraft leaving 180 miles to go. This value divided by 20 makes the end of the search 11 hours from the point at which the HH #1 arrived back on the scene.
6. If using the simple relationship referred to in note 4, we sum all the resources' effective miles giving us a total of 270 and divide this into the TSEM left to cover we get a number which is greater than 1, HH #1 must leave in 1 hours, so again we must apply the procedure above. Doing this we find that the search will be over in 2 hours with the total time searching being $2 + 5 = 7$ hours. Interestingly enough, besides the fact that we could not apply the simple relationship in this example, the time that the search is scheduled to be over is exactly the time when the HH #2 must leave the scene.

Table 3.4.4 A Search Case Example

4.0 THE POSTPROCESSOR

4.1 Overview Of The POSTPROCESSOR

At the discretion of the user, detailed information on each SAR case prosecuted by the simulation and the resources that participated on these cases, can be output to a file. Some of the data contained in this file is as follows:

- a. Case number and time of occurrence
- b. Case weather conditions
- c. Case latitude and longitude
- d. Information on the distressed unit
- e. Time spent searching, servicing demands, transiting, waiting, and dispatching
- f. Queue information
- g. Interrupt information
- h. Standby crew information
- i. Responding resource information including home station and cost.

To analyze this file, the user may use an information-retrieval package, such as IPF Report Writer, to make ad-hoc reports. When the file is no longer needed, it may be purged or copied to tape for long-term storage.

Whereas the regular printed output from the simulation provides summary statistics, the POSTPROCESSOR provides detailed data that the analyst may analyze. The POSTPROCESSOR allows the analyst to:

- a. Supplement the summary statistics so that the results of the simulation run can be more fully explained.
- b. Satisfy users that may feel that the summary statistics are inadequate.
- c. Examine results that are unexpected or questionable.

4.2 Description Of POSTPROCESSOR Data

As each case is processed by the simulation, detailed historical and computed case data are collected and filed in an output file for subsequent retrieval and postprocessing.

The detailed data files include for each case: a case record, resource record(s) for each resource that serviced the case, and a demand record(s) for each demand serviced by a resource.

The case record is depicted below:

1	2	3	4	5	6
RECORD TYPE	CASE NUMBER	TIME OF OCCURRENCE	SEASTATE	VISIBILITY	WIND SPEED
	7	8	9	10	11
	PATRON TYPE	TONNAGE	LATITUDE	LONGITUDE	DISTANCE OFFSHORE
	12	13	14	15	16
SEVERITY	TIME SLOT	NEAREST STATION	SERVING STATION	DISTANCE TO SCENE	
	17	18	19	20	21
STANDBY RECALLS	RECALLS UTILIZED	DISPATCH DELAY	TRANSIT TIME	WAIT TIME	
	22	23	24	25	26
LOCATE TIME	EXCESS WAIT TIME	TIMES IN QUEUE	TIME IN QUEUE	NUMBER INTERRUPTS	

Table 4.2.1 provides a list of the elements comprising the case record and gives an explanation of the recorded information where necessary. Each case record is also accompanied by a resource record for each resource serving on the case. The resource record is depicted below:

1	2	3	4	5	6
RECORD TYPE	CASE NUMBER	RESOURCE TYPE	HOME STATION	SORTIE TIME	SEARCH SORTIES
	7	8	9		
SEARCH TIME	NUMBER DEMANDS	TOTAL OPERATING COST			

Table 4.2.2 provides a list of the elements comprising the resource record and gives an explanation of the recorded information where necessary. Each resource record will be accompanied by one or more demand records depending on the number serviced by the resource. The demand record is depicted below:

1	2	3	4
RECORD TYPE	CASE NUMBER	DEMAND TYPE	SERVICE TIME

Table 4.2.3 provides a list of the elements comprising the demand record and gives an explanation of the recorded information where necessary.

TABLE 4.2.1
CASE RECORD DATA

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
1	RECORD TYPE	1, indicating record is a case record
2	CASE NUMBER	Case number assigned to the case
3	TIME OF OCCURRENCE	Time of case occurrence (decimal days)
4	SEASTATE	Seastate as calculated in OEM (feet)
5	VISIBILITY	Visibility as calculated in OEM (n. mi.)
6	WINDSPEED	Wind speed as calculated in OEM (knots)
7	PATRON TYPE	Type distressed unit (Reference 3)
8	TONNAGE	Gross tonnage of distressed unit
9	LATITUDE	Latitude of case (radians)
10	LONGITUDE	Longitude of case (radians)
11	DISTANCE OFFSHORE	Distance offshore as calculated in OEM (n. mi.)
12	SEVERITY	Severity as determined in the OEM (0=routine, 1=severe)
13	TIME SLOT	Time-slot of case occurrence (Weekday = 2 or Weekend = 1)
14	NEAREST STATION	Name of station nearest to the case
15	SERVING STATION	Name of station providing the first resource to service the case
16	DISTANCE TO SCENE	Distance traveled by first resource to arrive at scene (n. mi.)
17	STANDBY RECALLS	Number of standby crew recalls necessary to complete the case
18	RECALLS UTILIZED	Number of standby crews utilized
19	DISPATCH DELAY	Elapsed time between initial notification and dispatch of the first resource

20	TRANSIT TIME	Elapsed time between dispatch of the first sortie and its arrival on scene or in the search area
21	WAIT TIME	Elapsed time between initial notification and arrival of the first resource on scene
22	LOCATE TIME	Elapsed time between the first sortie's arrival in the search area and arriving alongside, i.e., securing the search activity
23	EXCESS WAIT TIME	Time in excess of input response criteria
24	TIMES IN QUEUE	Total number of times the case was queued
25	TIME IN QUEUE	Total amount of time the case was queued
26	NUMBER INTERRUPTS	Total number of times the case was interrupted by severe case needs

TABLE 4.2.2
RESOURCE RECORD DATA

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
1	RECORD TYPE	2, indicating record is a resource record
2	CASE NUMBER	Case number assigned to the case
3	RESOURCE TYPE	Resource type as input by the analyst (e.g., 41UTB)
4	HOME STATION	Name of resource's home station
5	SORTIE TIME	Total time resource was on all sorties (hours) for this case
6	SEARCH SORTIES	Number of times resource went out on a sortie searching on the case
7	SEARCH TIME	Total time spent searching (hours)
8	NUMBER DEMANDS	Total number of demands for which this resource provided service
9	TOTAL OPERATING COST	Total cost for the resource on this case

TABLE 4.2.3
DEMAND RECORD DATA

<u>ELEMENT NUMBER</u>	<u>ELEMENT NAME</u>	<u>DESCRIPTION</u>
1	RECORD TYPE	3, indicating record is a demand record
2	CASE NUMBER	Case number assigned to the case
3	DEMAND TYPE	Demand type for which service was provided
4	SERVICE TIME	Total amount of time servicing the demand

REFERENCES

1. National Bureau of Standards Reports, NBS Project 4314561, June 1971, Volumes I through V and Appendices A and B, A Search And Rescue Simulation Model For The United States Coast Guard.
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